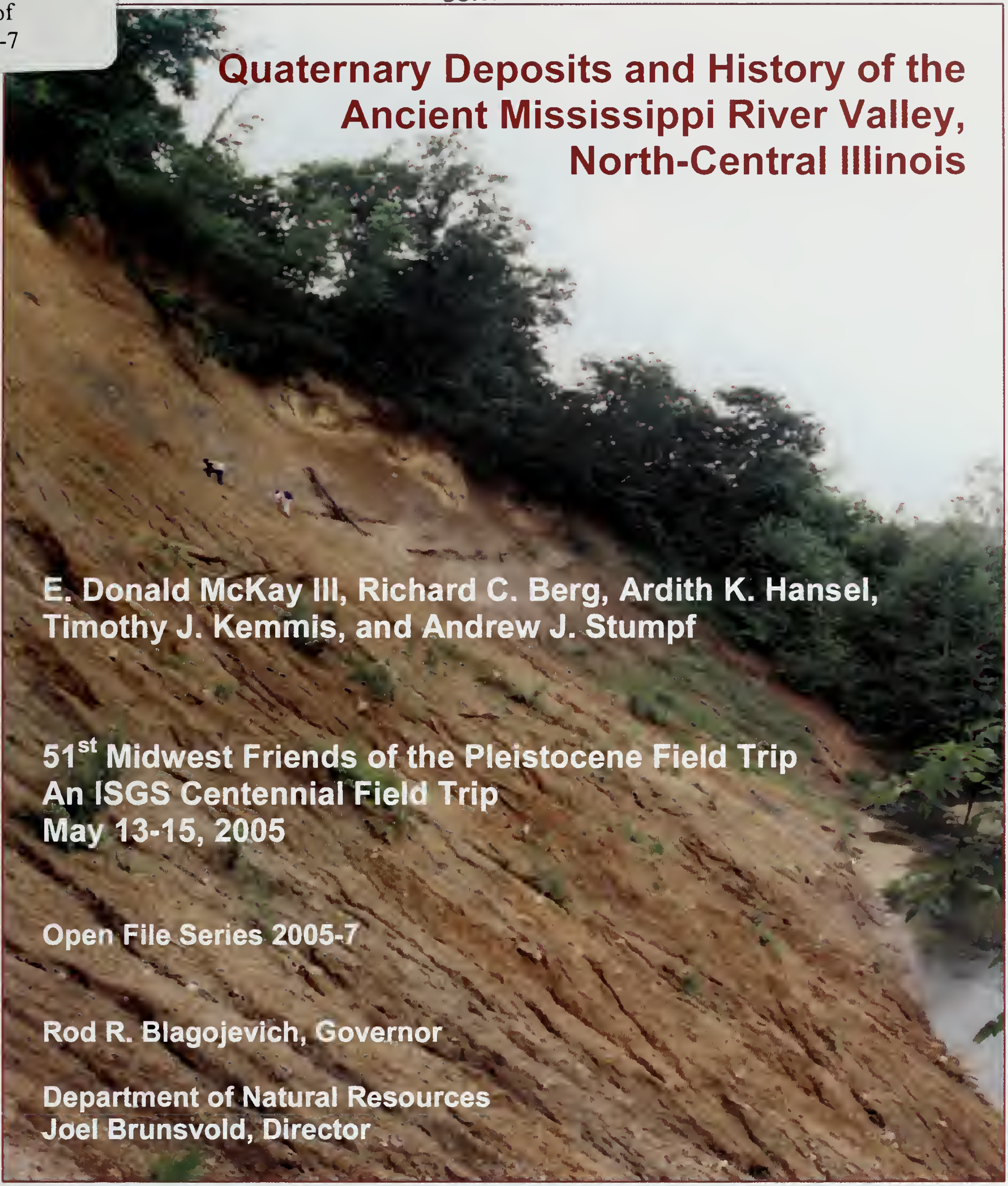


Quaternary Deposits and History of the Ancient Mississippi River Valley, North-Central Illinois

E. Donald McKay III, Richard C. Berg, Ardith K. Hansel,
Timothy J. Kemmis, and Andrew J. Stumpf

51st Midwest Friends of the Pleistocene Field Trip
An ISGS Centennial Field Trip
May 13-15, 2005

Open File Series 2005-7

Rod R. Blagojevich, Governor

Department of Natural Resources
Joel Brunsvold, Director

Illinois State Geological Survey
William W. Shilts, Chief

1905-2005 ISGS
Illinois State Geological Survey

DEDICATION

During this, the 2005-2006 celebration of the Centennial of the Illinois State Geological Survey, we dedicate this guidebook and field trip to the many ISGS scientists and affiliates who have contributed to the understanding of the Quaternary geology of Illinois by publishing their findings in ISGS reports and maps since the establishment of the ISGS on May 12, 1905.

Abert, Curtis C.
Anderson, Carl B.
Anderson, Richard C.
Athy, L.F.
Atwood, Wallace W.
Ball, John R.
Barnhardt, Michael L.
Barrows, Harlan H.
Berg, Richard C.
Bergstrom, Robert E.
Block, Douglas A.
Bogner, Jean E.
Bretz, J. Harlan
Brophy, John A.
Buhle, Merlyn
Butts, Charles
Cady, Gilbert H.
Carman, J. Ernest
Chamberlain, T.C.
Chrzastowski, Michael J.
Cobb, James C.
Culver, Harold E.
Curry, B. Brandon
Dey, William S.
Dixon-Warren, Antigone
Doyle, F.L.
Ekblaw, George E.
Emery, K.O.
Erdmann, Anne L.
Eveland, H.E.
Fenneman, N.M.
Fisher, D.J.
Flint, R.F.
Follmer, Leon R.
Foster, John W.
Frankie, Wayne T.
Fraser, Gordon S.
Frye, John C.
Gilkeson, R.H.
Glass, Herbert D.
Goldthwaite, James W.
Graham, Russell W.
Greenpool, Mary R.
Grimley, David A.
Gross, David L.
Hackett, James E.
Hajic, Edwin R.
Hansel, Ardith K.
Harn, Alan D.
Herzog, Beverly L.
Hester, Norman C.
Horberg, C. Leland
Hunter, Ralph E.
Jacobs, Alan C.
Johnson, W. Hilton
Jones, J.C.
Kay, F.H.
Kemmis, Timothy J.
Kempton, John P.
Killey, Myrna M.
King, Frances B.
King, James E.
Knappen, Russell S.
Krumbein, W.C.
Krumm, Robert C.
Kulczycki, David M.
Labotka, Theodore, C.
Lamar, J.E.
Landon, Ralph A.
Lanon, Mary S.
Larsen, Curtis E.
Larsen, Jean I.
Larson, David R.
Larson, Timothy H.
Leighton, Morris M.
Leonard, A. Byron
Lineback, Jerry A.
Luman, Donald E.
MacClintock, Paul
Masters, John M.
Maxey, G.B.
McComas, Murray R.
McGarry, Christopher S.
McGinnis, Lyle D.
McKay III, E. Donald
McKenna, Dennis P.
McLean, Melisa M.
Meents, Wayne F.
Meyers, Rebecca L.
Moore, David W.
Moran, S.R.
Nagy, Renee J.
Nebel, M.L.
Nelson, Robert S.
Nelson, W. John
Payne, J. Norman
Phillips, Andrew C.
Piskin, Kemal
Poole, Vicki L.
Potter, Paul E.
Powers, William E.
Pryor, Wayne A.
Pugin, Andre J.M.
Reeds, Chester A.
Reed, Phillip C.
Reinertsen, David L.
Riggs, Matthew H.
Ross, C.A.
Salisbury, Rollin D.
Sauer, Carl O.
Saunders, Jeffrey J.
Savage, T.E.
Searight, Walter V.
Selkregg, Lidia F.
Shaffer, Paul R.
Sharp, R.P.
Shaw, Eugene W.
Shilts, William W.
Sieving, John C.
Smith, Edward C.
Smith, Lisa R.
Socha, Betty J.
Specht, Susan A.
Steinmetz, John C.
Stephenson, David A.
Stiff, Barbara J.
Stoffel, Keith L.
Stohr, Christopher J.
Stumpf, Andrew J.
Styles, Bonnie W.
Styles, Thomas R
Taylor, Susan M.
Trask, C. Brian
Troost, Kathy G.
Trowbridge, Arthur C.
Udden, J.A.
Vaiden, Robert C.
Voskuil, W.H.
Wang, Hong
Wanless, Harold R.
Weibel, C. Pius
Weller, J. Marvin
Weller, Stuart
Wesley, Eugene
Westerman, Alfred A.
Wiant, Michael D.
Wickham, Jerry T.
Willman, H.B.
Zeizel, Arthur J.

Quaternary Deposits and History of the Ancient Mississippi River Valley, North-Central Illinois

E. Donald McKay III
Richard C. Berg
Ardith K. Hansel
Timothy J. Kemmis
Andrew J. Stumpf
Illinois State Geological Survey

51st Midwest Friends of the Pleistocene Field Trip
An ISGS Centennial Field Trip
May 13-15, 2005

Sponsored by
Illinois State Geological Survey
William W. Shilts, Chief
615 East Peabody Drive
Champaign, IL 61820-6964

ISGS Open File Series 2005-7

1905-2005 ISGS
Illinois State Geological Survey

Cover photo Andy Stumpf and Ardith Hansel studying the Clear Creek Section, NW, NW, NE Sec. 19, T. 32 N., R.1 W., Putnam Co., Illinois, Florid 7.5-minute Quadrangle. Photo by D. McKay.

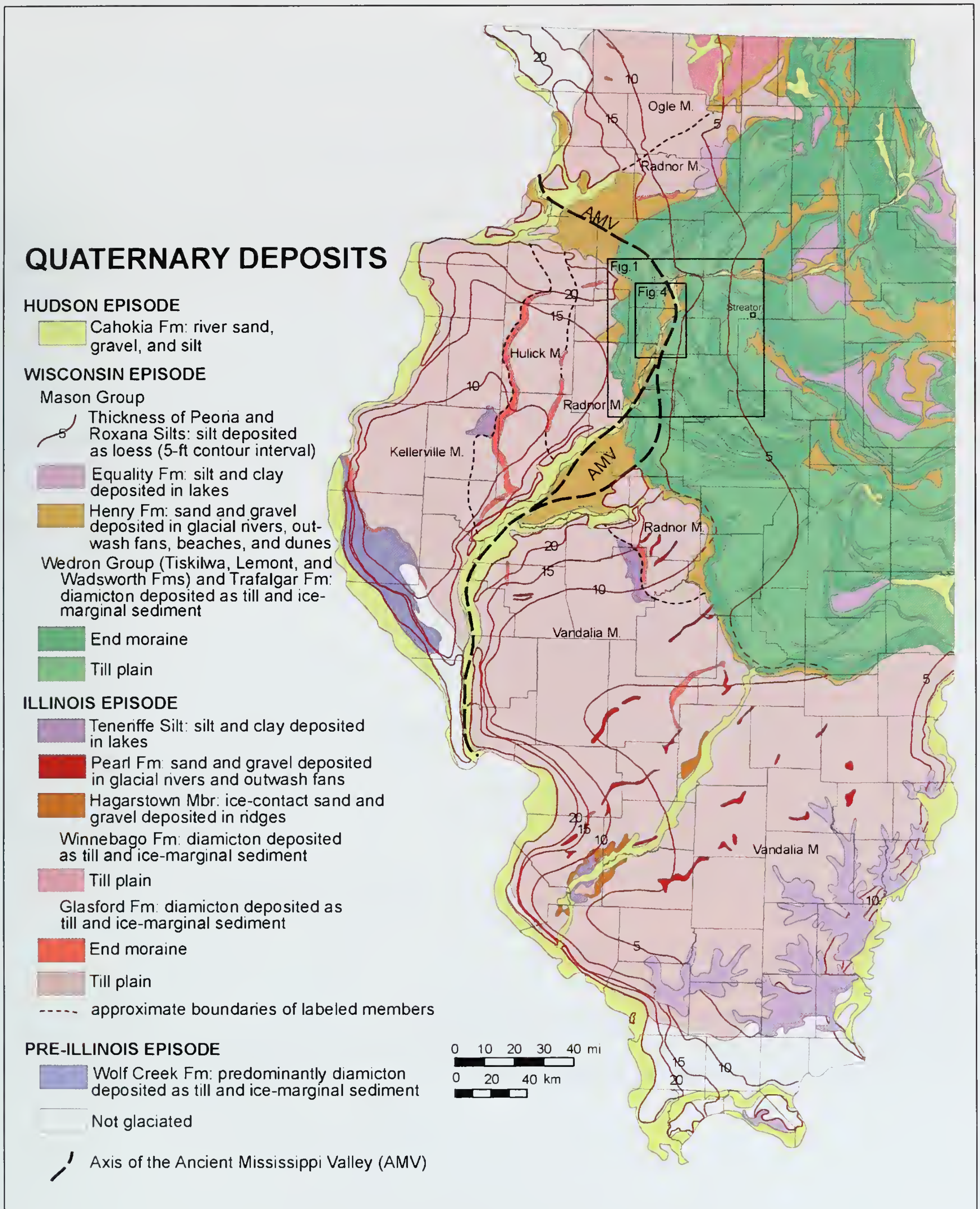


Plate 1. Quaternary deposits of Illinois (after Hansel and McKay in press).

CONTENTS

ACKNOWLEDGMENTS

The assistance provided by the Illinois Department of Transportation in funding geological mapping in the Middle Illinois River valley is gratefully acknowledged. Mary Mushrush coordinated logistics. Herb Glass, Adam Barnett, Phil DeMaris, Adam Ianno, Scott Koenig, and Karan Keith provided XRD analyses. Barb Stiff prepared and advised us on graphics. Christine Dellaria (Augustana College), Bob Darmody (University of Illinois), and Dave Voorhees (Waubonsee Community College) provided particle-size analyses. Lisa Smith provided GIS support. The ISGS drilling team, Jack Aud, Chris Wilson, Steve Wildman, and Joe Hutmacher, collected over 2500 feet of continuous core and provided help with section cleaning and bridge building. Mark Hahn, Ken Knapp, Jim Monderella, Tom Nauman, Jim Taylor, Gene Schoepke, Judy Schmidt, Lois Lindstrom, and the Village of Hopewell gave us permission to drill test holes and/or bring the field-trip participants on their property. We also thank Midwest Material Company, Richard Walsh president, for providing facilities and services for the field trip and support for our ongoing research at their site near Lacon. We thank Jon Goodwin for reviewing the manuscript.

INTRODUCTION

During most of Quaternary time, the Mississippi River, which has its modern headwaters more than 500 miles north of the field trip area, flowed through central Illinois, draining the central mid-continent region and a substantial portion of the southern margin of several continental ice sheets. Several continental glaciers entered Illinois, overrode, and buried the river valley, preserving the sediments that contain a record of the events that impacted the watershed during the latter half of the Quaternary. Recent mapping along the buried ancient course of the Mississippi River in north-central Illinois (Plate 1) has provided an opportunity to take a fresh look at the succession of deposits that fill the valley and provided insight into the details of the region's rich Quaternary record.

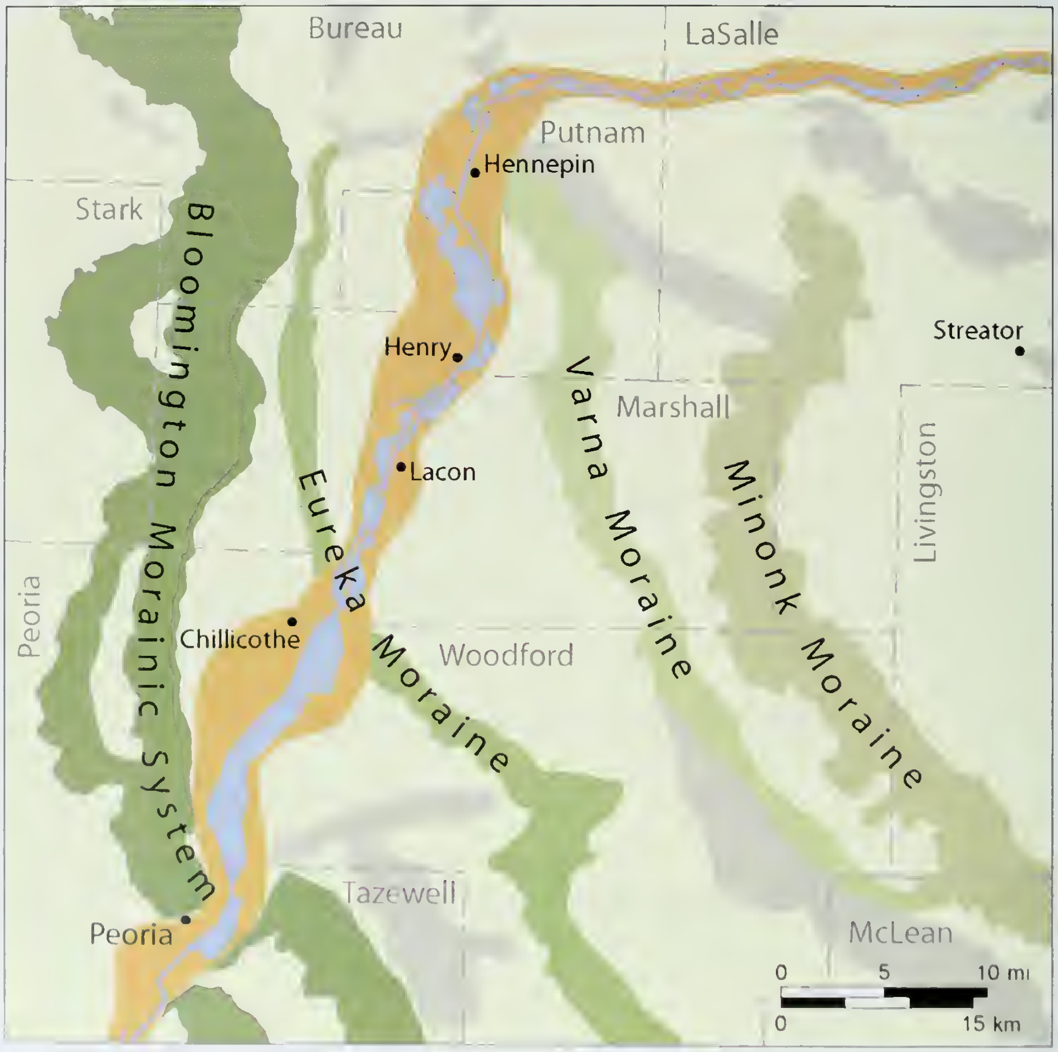


Figure 1. The Illinois River valley (gold) and principal moraines in north-central Illinois. Refer to Plate 1 for outline of area shown. Moraines noted in text are labeled. Others are shown in gray.

The Mississippi River no longer flows through central Illinois. Nearly 20,000 ^{14}C years ago it was diverted to its present course during the last of its several encounters with the Lake Michigan glacial lobe. Today, the modern Mississippi River forms the western boundary of Illinois more than 80 miles west of the field trip area. The present Illinois River (Fig. 1), which formed as the late Wisconsin Episode Lake Michigan Lobe retreated from its terminus, occupies part of the old valley and drains much of northeastern Illinois. On this field trip, we will examine surface exposures and discuss data from cores of the succession of glacial, proglacial (fluvial, lacustrine, and loessal) and interglacial deposits and paleosols along the Ancient Mississippi River valley and in the Illinois River valley. We will study a complex sedimentary record marked by significant unconformities.

Today, the Illinois River serves as one of the nation's major commercial transportation corridors, linking Chicago on Lake Michigan with the Gulf of Mexico. The field trip will traverse portions of Marshall, and Putnam Counties along the middle Illinois River north of Peoria, Illinois, in a largely rural area with major agricultural production, gradual growth via suburbanization, historic coal mining, ongoing aggregate mining, and substantial groundwater resource potential. Impetus for our recent work in the area came from a need for geologic information to assist the planning and design of a highway upgrade proposed for Illinois Route 29, which parallels the west bank of the Illinois River north of Peoria from Chillicothe to the "big bend" in the river near Hennepin. Detailed geologic information was particularly important for highway planning in this case because of the presence of environmentally sensitive resources and habitats. Geologic mapping by ISGS staff was begun in 2001 with significant support provided by the Illinois Department of Transportation (IDOT). This mapping expanded upon mapping along the Illinois River near Peoria (see Stumpf and Weibel in press). New drilling and field mapping done for the IDOT project included 1:24,000-scale mapping and 3-D modeling of five 7.5-minute quadrangles in the region. Most of the sites we will visit were discovered and/or worked in greater detail during that mapping project.

Regional Setting

The middle reach of the Illinois River is set in a large, deep valley ranging in width from less than two miles to nearly seven miles. Its valley floor is as much as 90 m (300 ft) below the adjacent upland (Plate 2, Fig. 1). Several large Wisconsin Episode terraces rise as much as 30 m (100 ft) above the normal pool elevation of the Illinois River and typically comprise the most extensive parts of the valley floor. The meander belt of the modern Illinois River occupies a narrow portion of the valley. It is joined by short and steep tributary streams, which drain the uplands east and west of the valley. The present Illinois River is a low-gradient channelized river with extensive (but shallow) backwater lakes, a narrow, low-lying floodplain, and numerous tributary-deposited alluvial fans.

Tributary streams are deeply incised into the uplands and expose Wisconsin and Illinois episode glacial and fluvial deposits and bedrock that we will examine on the trip. Gently

rolling uplands adjacent to the valley are crossed by several broad, low, end moraines (Fig. 1) that range in width from less than a mile to several miles and mark successive margins of the Wisconsin Episode glacier as the ice front paused during its general northeastward retreat toward the Lake Michigan basin. Some end moraines mark readvances during this retreat.

The names Middle Illinois River and Middle Illinois River Valley (MIV) apply to that reach of the modern Illinois River and its valley between Hennepin and Peoria. Earlier courses of the Mississippi River flowed through this region, and the names Ancient Mississippi River (AMR) and Ancient Mississippi River Valley (AMV), respectively, are applied to the ancient river and its valley. The local bedrock valley, which was named the Middle Illinois Bedrock Valley (MIBV) by Horberg (1950), is generally parallel to but a few miles wider than today's MIV.

Previous Investigations

The Illinois River valley was the focus of a number of early glacial stratigraphic studies in Illinois (Leverett 1895, 1899; Leighton 1926, 1931, 1933; and Leighton and Willman 1950). Detailed work by Horberg (1950, 1953) and McComas (1968) in the Middle Illinois River valley summarized the glacial geology and groundwater conditions, focusing on the widespread and productive Sankoty aquifer. Willman (1973) published a summary report and a set of 1:62,500-scale maps covering the Illinois Waterway. The area was also the focus of the 26th Midwest Friends of the Pleistocene field trip (Follmer et al. 1979). Recent large-scale geologic mapping in the Peoria area by the authors began in 1996 and has provided insights into the glacial and bedrock geology of the area (Weibel and Stumpf 2001, Stumpf and Weibel 2005, McKay et al. in press).

Methods

Samples of Quaternary deposits were collected from 125 surface exposures and from more than 800 m (2600 ft) of continuous core from fifteen new boreholes. Grain-size was determined using pipette, sieve, and hydrometer analyses. Size fractions reported are sand (2.0 to .062mm), silt (.062 to .004mm), and clay (<.004mm). Silt fractions used are coarse (.062 to .032mm), medium, (.032 to .016mm), fine (.016 to .008mm), and very fine (.008 to .004mm). Clay is reported as <.004mm for diamicton samples and <.002mm for loess and paleosols. Clay minerals were determined by X-ray diffraction analyses of glycolated oriented clay (<.002mm). Calcite and dolomite percentages were determined by X-ray diffraction peak heights of bulk powder packs. Wood fragments, plant debris, and organic paleosols were collected for ^{14}C dating. Ages are reported in ^{14}C years before present (^{14}C yr BP) and in calibrated years before present (cal. yr BP). Ages were calibrated with the CALPAL program http://www.calpal-online.de/

Stratigraphic Nomenclature

Major lithostratigraphic and pedostratigraphic units for the glacial and interglacial episodes of the Quaternary Period in Illinois are shown in Figures 2 and 3. Diachronic

temporal units, episodes and subepisodes, are used. These are based on events that begin and end at different times in different places and are interpreted from lithostratigraphic and pedostratigraphic units (Hansel and Johnson 1996, Johnson et al. 1997, Karrow et al. 2000). Because of correlation uncertainties and a paucity of age determinations of the oldest Quaternary deposits, glacial and interglacial episodes that predate the Illinois Episode are referred to collectively as the pre-Illinois Episode. The latest part of this time, based on the Yarmouth Geosol, is referred to as the Yarmouth episode.

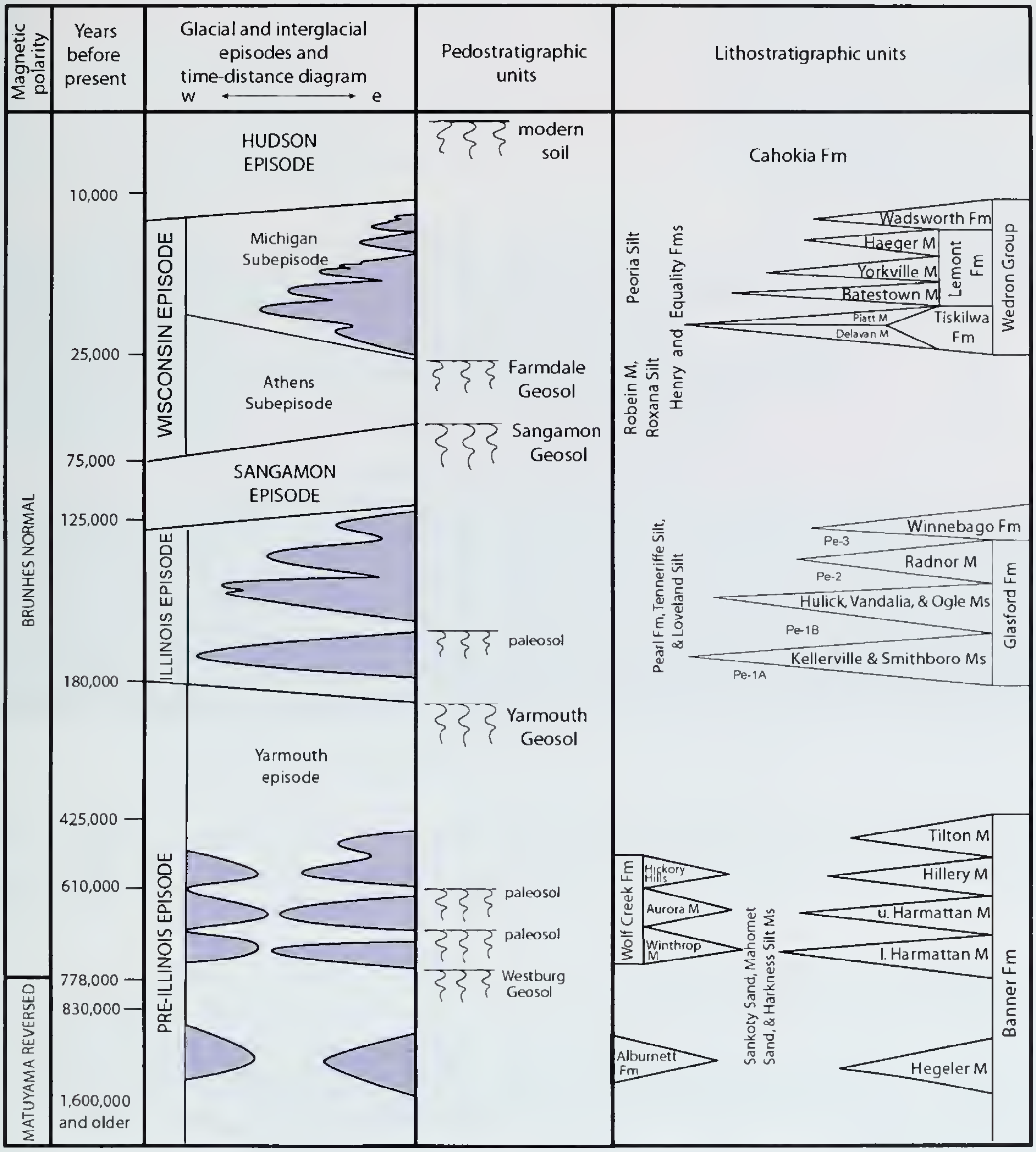


Figure 2. Timetable of Quaternary glacial and interglacial events and primary lithostratigraphic and pedostratigraphic units on which they are based in Illinois (after Hansel and McKay, in press). Pe-1A, Pe-1B, Pe-2, and Pe-3 are informal tongues of the Pearl Formation recognized in the Ancient Mississippi River valley in north-central Illinois.

The lithostratigraphic classification and terminology used herein follow those of Hansel and Johnson (1996) for the Wisconsin Episode and Willman and Frye (1970) for older deposits. Stratigraphic units that occur in the AMV in central Illinois are presented and discussed in detail in Appendix A, and are shown here in table form (Fig. 3) and in schematic cross section (Fig. 4).

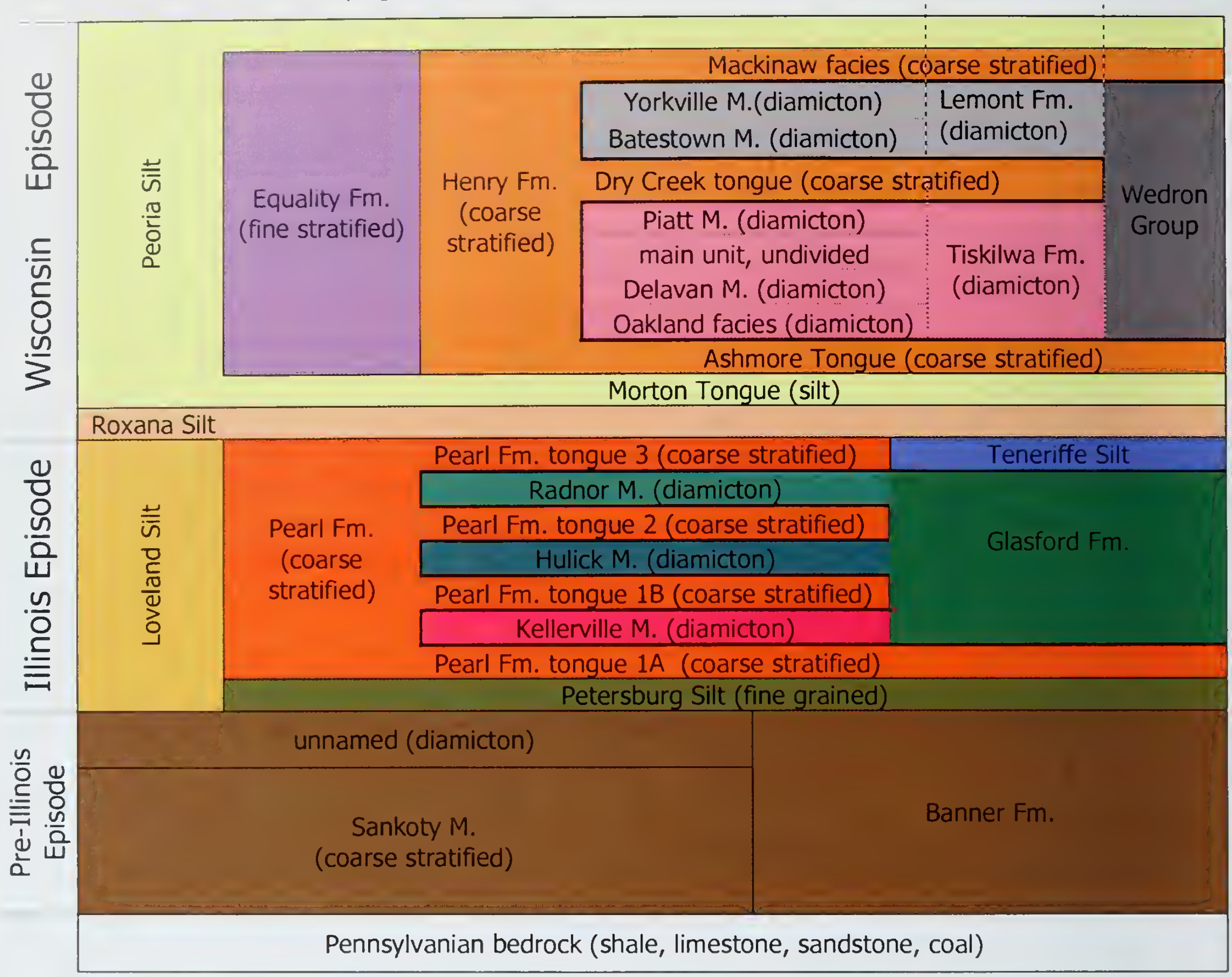


Figure 3. Quaternary lithostratigraphy of the Middle Illinois River valley region in north-central Illinois. Parentheses indicate the principal lithology of lithostratigraphic units.

Differentiation of Diamictons

Reliable differentiation of similar diamictons is key to correlation of diamictons and units that intertongue with them and, thus, to successful reconstruction of Quaternary stratigraphy and events. As previously noted, diamictons deposited in Illinois by glacial lobes from different spreading centers differ significantly in mineralogy. All of the AMV diamictons sampled to date, however, appear to have been deposited by the Lake Michigan lobe, and mineralogic and lithologic differences between them are subtle. The exception is the red diamicton of the main body of the Wisconsin Episode Tiskilwa

Formation, which makes it a particularly distinctive mapping unit. The upper and lower diamicton members and facies of that formation, however, are gray and resemble the several, gray, Illinois-Episode diamictons. Analyses of grain size and mineralogy have been used successfully for many years to characterize and guide correlations of diamictons, and both parameters are considered a reliable means for correlation in the AMV area, providing that sufficient analyses of in-unit variability are available. Valuable too, are marker beds (Wisconsin Episode loesses and the Sangamon Geosol) present in the AMV (Figs. 3 and 4).

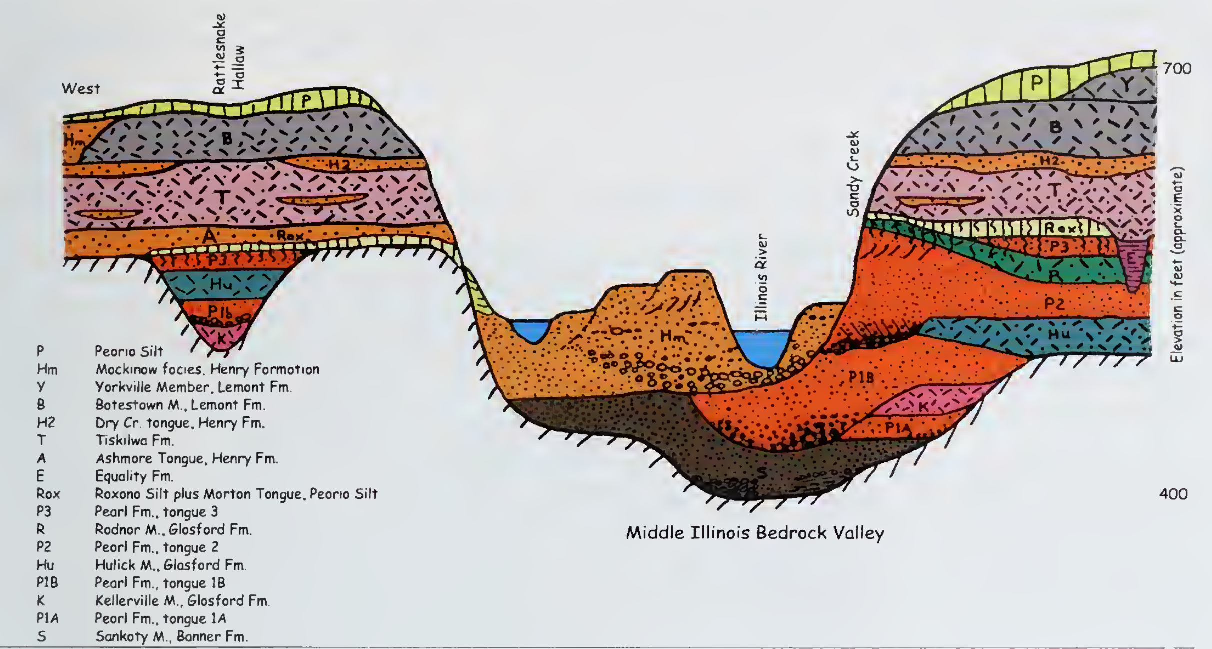


Figure 4. Generalized cross section of the Middle Illinois River valley showing principal lithostratigraphic units present at the approximate latitude of Henry, Marshall County, Illinois.

QUATERNARY HISTORY OF THE ANCIENT MISSISSIPPI VALLEY

Heritage of Large Rivers and Glaciers

The AMR in north-central Illinois has been repeatedly overridden and blocked by continental glaciers, and during the last glaciation, it was diverted to its modern channel. The impacts of these events on the region and particularly on its sedimentary record were complex and varied. Much of that history is recorded in thick fills of sediment in the bedrock valley (Middle Illinois Bedrock Valley) occupied and reoccupied by the AMR (Fig. 5).

Each time glaciers entered the headwaters of the AMV, large volumes of sediment-laden water passed into the fluvial system, and aggradation occurred in the main valley.

Base level rose and slackwater lakes were ponded locally in tributaries. Silt, eroded from barren floodplain surfaces, was deposited as loess on adjacent uplands. Thick sand and gravel were deposited in the main stem. When the advancing glacier crossed the valley, it blocked the river and created a large lake northwest of the blockage. As the ice crossed the valley it deposited diamicton over the stratified valley-fill, nearly infilling the entire valley with drift. During glacial retreat, the river returned to a course near its former one and the valley was incised during a complex series of events. Drainage originating at the ice margin in the headwaters of the watershed cut deeply into the newly exposed deposits. Lakes, some behind morainal dams in the upper Illinois River, retained water temporarily, but ultimately burst their containment, releasing large jökulhlaup-type floods that swept down the valley, helping to incise the channel and cut terrace levels. This scenario was repeated at least six times.

During the last encounter between the Lake Michigan Lobe and the Ancient Mississippi River, the river was diverted to its present course, but earlier, during the middle and late Quaternary, the river persisted, returning to its course through north-central Illinois several times. Because this pattern of events was repeated, the glacial and fluvial deposits present today are complex, and the Quaternary history recorded in those sediments of one of the largest drainage systems in mid-continental North America is rich. The challenges to reconstructing this history are several. Deep exposures containing multiple units are rare. Evidence, particularly from the earliest Quaternary, is scant, and can be retrieved only by drilling. Erosion events periodically removed

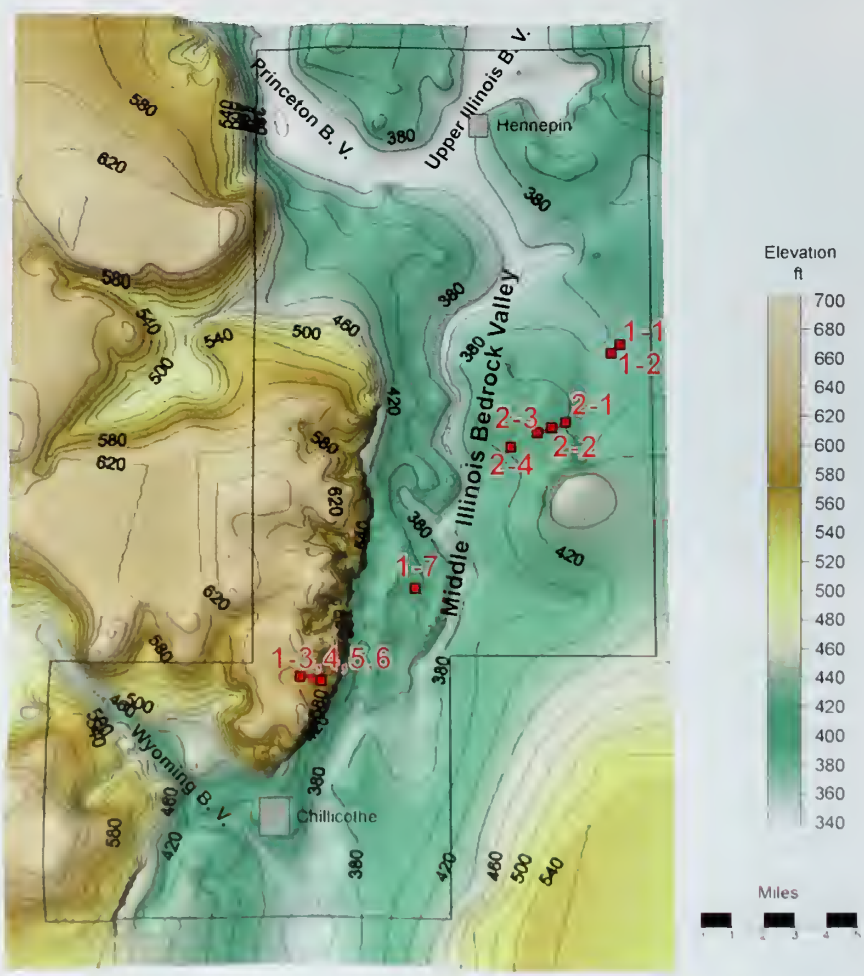


Figure 5. Bedrock topography and bedrock valleys in the Middle Illinois River valley area of north-central Illinois between Hennepin and Chillicothe from bedrock surface model by D. Keefer. Field trip stop numbers are shown in red. Outline of area shown is indicated on Plate 1.

much of the preceding record. Radiometric and other age determination techniques, although promising, have not been applied to pre-Wisconsin sediments in the area. Outcrop and core studies, with available seismic results, can be used to reveal the major components of the sedimentary record and to develop a stratigraphic model for the deposits, but data are insufficient at present to allow us to map the complexities of these deposits in the subsurface at large scale.

Briefly, sedimentary evidence presently available indicates that glaciers overrode the AMV in north-central Illinois at least once prior to the Illinois Episode, three times during the Illinois Episode, and twice during the Wisconsin Episode. The following sections discuss the available evidence and its implications for glacial and valley history.

Pre-Glacial Record

No sediment is known to exist in central Illinois that might record the first million or so years of the Quaternary (Fig. 2). Understanding of early Quaternary history of the region is based largely upon the morphology of the pre-glacial bedrock surface (Fig. 6) interpreted from water-well and test drilling records. Leverett (1899), using scant subsurface data available to him at the time, suggested that the preglacial Mississippi River flowed southeastward across northwestern Illinois, joining the preglacial Fox River, and turning south near Hennepin to proceed along the course of the MIV. Horberg (1950) used an extensive collection of well records to map the course of the AMV and other bedrock valleys in detail. The bedrock surface in the MIV area (Fig. 5) includes gently rolling shale slopes and limestone-capped uplands cut by the deep, wide AMV and its several large tributary valleys (Horberg 1950, Weibel et al. 2003). The Pennsylvanian rocks of the area also include sandstone and several coal seams. The oldest deposits overlying the Paleozoic bedrock in north-central Illinois contain crystalline erratics and are considered Quaternary (pre-Illinois Episode) in age.

Pre-Illinois Episodes

In the field trip area, the pre-Illinois Episode glacial record is poorly known. Deposits that might date to pre-Illinois Episode events are thin and sampled only in the subsurface. Although no absolute age determinations are available locally, regional evidence of dated pre-Illinois deposits in Illinois, Missouri and Wisconsin are helpful in reconstructing the history.

The Ancient Mississippi Valley lies at the juncture between northwestern-derived (Keewatin) and northeastern-derived (Labrador) pre-Illinois Episode glacial advances (Fig. 6b). The southern limit of pre-Illinois Episode deposits in Illinois occurs 320 km (200 mi) south of the MIV. Earlier studies postulated that the MIBV developed as a consequence of pre-Illinois Episode ("Kansan and Nebraskan") glaciations that advanced into Illinois from the northwest and northeast (Horberg 1950, Willman and Frye 1970). It was thought that these early glaciers did not override the AMV but stopped short of it, standing at limits to the west and to the east of the valley (Fig. 6b), thus, displacing preglacial drainage into a proglacial ice-marginal channel and creating

the AMV. Reversed paleomagnetic signatures from sediments in tributaries to the upper Mississippi suggest that the river north of Illinois was deeply entrenched prior to 790,000 and perhaps as much as 2.1 million years ago (Baker et al. 1998). The question remains, however, were the upper Mississippi and AMR of central Illinois connected at that early time?

Pre-Illinois Episode glacial sediments are widespread both west and east of the AMV

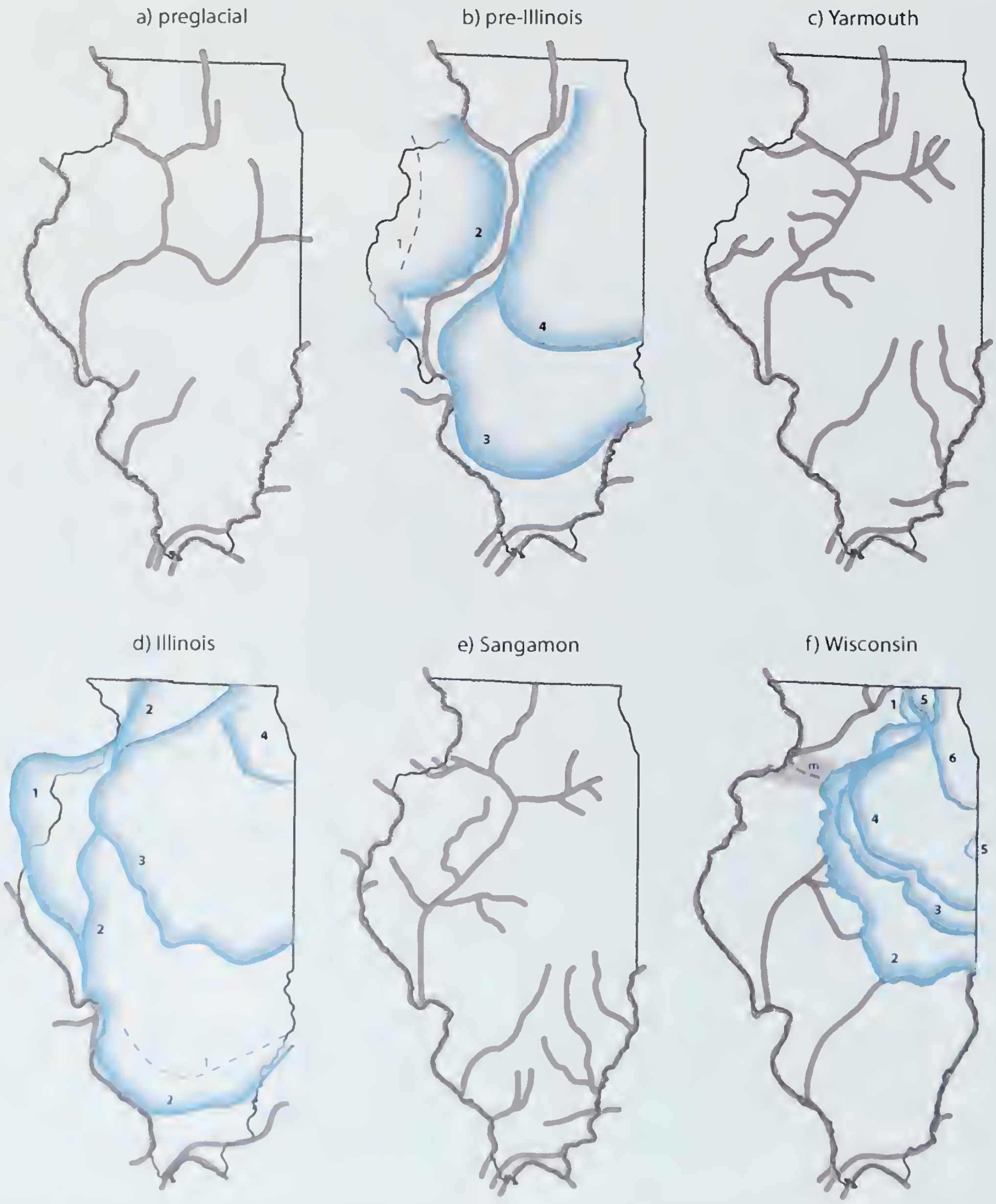


Figure 6 Maps showing Quaternary drainage history and inferred maximum ice-margin positions in Illinois during a) preglacial, b) pre-Illinois, c) Yarmouth, d) Illinois, e) Sangamon, and f) Wisconsin episodes. Numbers indicate sequence of ice-margin positions (after Hansel and McKay, in press). Wisconson Episode Glacial Lake Milan is indicated by symbol "m".

(Fig. 6b, Plate 1). West of the AMV they were deposited by ice from a northwestern (Keewatin) spreading center. In western Illinois, these deposits have mineralogical compositions dominated by western sources and are correlated with the Wolf Creek and Alburnett Formations of Iowa (Hallberg 1980, Wickham 1979) (Fig. 2). They are high in expandable clay minerals and low in carbonate content, similar to bedrock and diamictons in Iowa. Paleomagnetic data from western Illinois and Iowa suggest that the older of these units predate the Brunhes-Matuyama geomagnetic reversal at about 778,000 years ago (Hallberg 1986, Miller et al. 1994). Age determinations based on cosmic-ray produced radionuclides, ^{26}Al and ^{10}Be, in intercalated paleosols and tills at a site 300 km (200 mi) southwest of the field trip area in Missouri indicate that the tills there are older than 1.6 million to 2.4 million years (Balco et al. 2005). These results indicate that the glacial lobe (presumably from the Keewatin spreading center) was extensive very early in the Quaternary (pre-Quaternary?). If glacier(s) reached the latitude of St. Louis very early, they might have also entered western Illinois and influenced early Mississippi River drainage. Units with mineralogies of the Wolf Creek and Alburnett Formations have not been found in the MIV area.

East of the AMV, pre-Illinois glacial sediments are widespread. These sediments have mineralogical compositions that distinguish them from western-source deposits. Rich in illite, calcite, and dolomite (Johnson et al. 1971, Johnson et al. 1972, Johnson 1986, Kempton et al. 1991), they were deposited by glaciers flowing from the northeastern (Labrador) glacial spreading center and are included in the Banner Formation in Illinois (Willman and Frye 1970, Fig. 2). The mineralogy of some of these deposits is difficult to distinguish from that of the Illinois Episode deposits, which also had a northeastern source (Fig.6b).

Thin illite-rich, dolomitic diamictons have been found recently in the deep subsurface in three cores in the field trip area. They lie near the bottom of the AMV at elevations of about 122 m (400 ft). Their mineralogy is similar to the composition of a Lake Michigan lobe “Kansan” till described by Johnson (1964) from areas southeast of the field trip. If these deposits are pre-Illinois Episode tills, then this evidence would suggest that the MIBV was deeply incised prior to at least one pre-Illinois Episode glaciation, which then overrode the valley.

Yarmouth Episode

The Yarmouth episode was an extraordinarily long interglacial period in Illinois that is represented by a very well developed paleosol, the Yarmouth Geosol in western and southern Illinois, where it is developed in pre-Illinois Episode drift (Figs. 2 and 6c). The deep weathering of the Yarmouth profile is more than twice the thickness of the Sangamon Geosol in the same area (Willman and Frye 1970). Some (Grimley et al. 2003) have recently suggested that the time required for Yarmouth Geosol formation was more than three times the 50,000 years estimated for Sangamon Geosol formation. An intact profile of the Yarmouth Geosol in central Illinois should be a deeply weathered and distinctive feature, however neither intact Yarmouth paleosol profiles, nor evidence of weathering (truncated or otherwise) has been found in the study area that is

attributable to the Yarmouth episode. Widespread erosion, for which there is abundant evidence, is suspected to have removed the ancient soil.

The AMR is thought to have flowed through central Illinois during the Yarmouth episode, and some of its deposits (Sankoty Sand Member) previously interpreted as pre-Illinois Episode outwash, may date to the Yarmouth episode. This will be discussed more later.

Illinois Episode

A deep AMV existed when the first Illinois Episode glacier from the northeast (Lake Michigan lobe) reached the area, and the valley was overridden during that and each of two later Illinois Episode glacier advances. Limits of these three advances are 150, 80, and 30 km (95, 50, and 20 mi.) west of the valley (Figs. 2 and 6d and Plate 1). The earliest Illinois Episode glacier advanced farthest west, and the youngest was least extensive. Diamicton of the oldest advance overlies pre-Illinois Episode till and the Yarmouth Geosol in eastern Iowa (Wickham 1979, Hallberg 1986). These well-documented glacial advances deposited diamictons composed of debris with Lake Michigan lobe compositional affinities, i.e. dolomite content higher than calcite, illite content greater than expandables, and lobe-specific erratics, such as a distinctive jasper-rich conglomerate. Our research in the Middle Illinois Valley area indicates that significant thicknesses of AMR deposits occur between the three till units in the AMV. This result confirms that retreats and readvances occurred across the AMV area during the Illinois Episode. Earlier work (Willman and Frye 1970, Lineback 1979b) has cited evidence of soil development (Pike Geosol) on the oldest diamicton as indicative of a significant hiatus between early and middle Illinois Episode advances. Weathering has not been found in early Illinois Episode sediments in the MIV area, and the time required for the retreats-readvances remains unknown.

Following each Illinois Episode retreat, the AMR reoccupied a course within the prior AMV (although not its exact same course), downcut into the deposits that filled its previous courses, incised its main stem, developed new tributaries, built terraces and levees, and flooded slackwater lakes. With each incision, the river eroded large parts of the older record and left only remnants of former valley fills. The valley was probably a significant loess source periodically, but Illinois-Episode loesses are rarely preserved in the field trip area. As the last Illinois Episode glacier retreated from central Illinois into the northeastern part of the state, meltwater and sediment from that ice front and ice elsewhere in the headwaters of the AMR may have continued to impact the AMV in Illinois until the onset of the Sangamon Episode.

Sangamon Episode

At the end of the Illinois Episode, uplands along the AMV in central Illinois resembled the modern landscape. The main valley was flanked by till-plain uplands and deeply incised tributaries. During the Sangamon Episode, the AMR was at a relatively low elevation in central Illinois (Fig. 6e) and the adjacent uplands were 15 to 30 m (50 to 100 ft) lower in elevation than their modern counterparts. Preserved on that former

Sangamon Episode landscape are weathering profiles of the Sangamon Geosol (Figs. 2 and 4). Common are upland soils, but also preserved are soils that developed in fluvial sediments, mainly in former tributaries to the AMV. To date, no Sangamon Episode alluvial deposits from the main stem of the AMV have been identified. It is likely that Wisconsin Episode meltwater eroded Sangamon Episode deposits and soils from the main stem of the AMR system.

Wisconsin Episode

The record of events of the early Wisconsin Episode (Fig 2.) prior to about 50,000 ^{14}C yr BP in central Illinois is contained in the upper part of the profile of the Sangamon Geosol and in deposits of a few lakes and bogs that have been sampled for pollen and fossils (Curry and Baker 2000). About 50,000 ^{14}C yr BP, an early Wisconsin glacier entered the headwaters of the AMR's watershed north of Illinois, and the AMV in central Illinois began to aggrade. Loess deposition began about that time on adjacent uplands and continued with only minor cessations for nearly 25,000 years. Loess deposition paused briefly between about 28,000 or 30,000 and 24,500 ^{14}C yr BP, when ice retreated from the upper watershed. During this time a weak soil profile, the Farmdale Geosol, formed in the upper part of the first Wisconsin loess (Roxana Silt). With the advance of the late Wisconsin Episode glacier into the headwaters of the AMV about 24,500 ^{14}C yr BP, outwash transport resumed along the AMR (McKay 1979) and deposition of late Wisconsin Episode loess (Peoria Silt) began. Shortly after this onset highly dolomitic loess marked the introduction of dolomitic outwash from the Lake Michigan and/or Green Bay lobes into the watershed.

The advancing Lake Michigan glacier crossed northeastern Illinois, reached the AMV about 20,350 years ago (Curry 1998), and blocked the Mississippi drainage, forming Glacial Lake Milan north of the blockage (Fig. 6f, Plate 1). The AMR spilled over a divide at Rock Island and was diverted into its present course. As the Lake Michigan glacial lobe retreated into northeastern Illinois, its terminal moraine, the Bloomington Morainic System to the northwest of the MIV (Fig. 1), was not breached by the Mississippi, and the post-diversion AMV was left nearly filled with Wisconsin glacial and fluvial deposits. The thickest and most prominent diamicton in the area, the reddish-brown and loamy Tiskilwa Formation, was deposited during this event.

Glacial retreat northward toward the Lake Michigan basin was characterized by numerous still stands and readvances. Locally, the Wisconsin Episode glacier built several end moraines. The Eureka Moraine, west of the FOP field-trip area, is composed of olive brown to gray, loamy diamicton (Batestown Member) that overlies the red Tiskilwa Formation. In the eastern part of the field trip area, the Varna Moraine marks a readvance and is approximately the western extent of olive brown to gray silty clay loam textured diamicton (Yorkville Member). As the Wisconsin glacier retreated, meltwater from the Lake Michigan, Saginaw, and Erie lobes, following a sag in the land surface above the buried AMV, incised and widened the MIV. Late in the retreat, large volumes of meltwater that discharged into headwaters of the Kankakee and upper Illinois River valleys created periodic “torrents”. It has been suggested that a single

massive release may have incised and widened the Illinois River valley, carving several of the prominent terraces and giving the valley much of its present geomorphology (Willman and Frye 1970, Hajic 1990).

Hudson Episode (recent)

The postglacial Illinois River inherited an oversized, meltwater-deepened valley. Compared to its glacier-fed ancestors, the low-gradient modern river has little power to modify its valley. Throughout the Hudson Episode the modern channel has migrated within a narrow meander belt, creating bars, natural levees, and backwater lakes. It gradually has blanketed the lowest-level outwash terrace with overbank silt and clay. Today, tributaries deliver more sediment to the main stem than it can remove, creating large alluvial fan deltas where tributaries enter the main valley.

Summary of Ancient Mississippi Valley History

The complex history of the AMV in central Illinois is decipherable with sufficient observations, and recently collected cores, seismic surveys, and new age determinations have provided pertinent information not available to previous workers that help clarify the history. Despite the newly available data, however, some important questions remain unanswered. The reconstruction of the history of valley fill in the AMV between Hennepin and Chillicothe, shown in Figure 7, is based on the best available evidence. The elevations and stratigraphic relations of fluvial deposits in the AMV are a key to piecing together the history. Relative ages of units are determined largely from their correlation into the succession of glacial diamictons, marker beds, and paleosols with which they intertongue. Prior models for valley fill applied to the AMV area suggested that interglacial episodes (Afton, Yarmouth, Sangamon, and recent) have been intervals of river incision and that glacial episodes have been intervals of significant aggradation in the alluvial system (e.g., Horberg 1953). Data collected during recent mapping in the MIV allow refinement of this simplistic geomorphic model, and reveal new stratigraphic evidence that infers ages for valley-fill units previously considered of uncertain age. The absence of absolute ages for pre-Wisconsin Episode deposits, however, leaves significant room for further refinement of these interpretations.

The Sankoty Sand Member of the Banner Formation has been considered to be the oldest valley-fill deposit and to be pre-glacial, “Nebraskan”, or “Kansan” in age (Horberg et al. 1950, Horberg 1953, Willman and Frye 1970). The Sankoty has been described as having a “distinctive” lithology (typically red, quartz-rich, well-rounded medium to coarse sand; see Appendix A), but our data show the widely mapped unit to contain many deposits that differ significantly from the “distinctive” lithology. Our observations show that, not only is the Sankoty Member over-mapped and likely a composite of several units, but also the “distinctive” Sankoty lithology is not unique but recurs in later Illinois and Wisconsin Episode elements of the valley fill deposits. Thus, in our work we have restricted the term Sankoty Sand Member to deposits that are demonstrably pre-

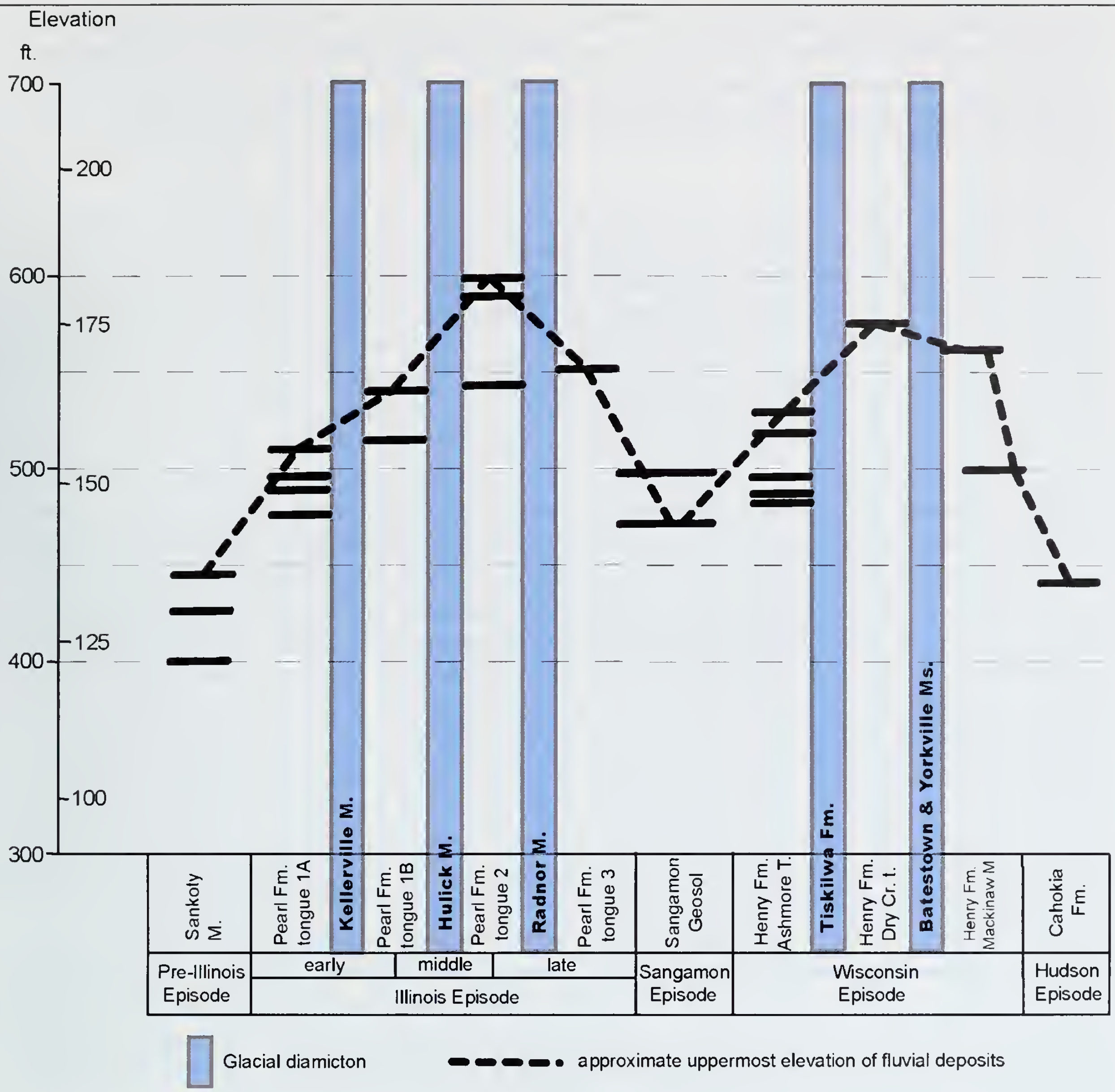


Figure 7. History of changes in elevation of the surface of fluvial deposits in the Ancient Mississippi and Middle Illinois River valleys in north-central Illinois.

Illinois Episode in age. Such deposits occur deep in the AMV, mostly below the elevation of 145 m (475 ft) (Fig. 7). Three recent cores, in particular, show that a red sand that underlies the oldest Illinois Episode diamicton also underlies a thin, probably pre-Illinois Episode diamicton at elevation 122 m (400 ft). The absolute age of this Sankoty sand, however, remains unknown.

The elevation, stratigraphy, and composition of this pre-Illinois Episode Sankoty sand suggest that it may date to an interglacial episode. It has very low carbonate content, suggesting derivation from a weathered landscape and/or from a low carbonate source area, such as the upper Mississippi River valley. We have not, however, found a

paleosol developed in the deposit. Red stains on the quartz grains give it its red color. Perhaps the origin of those stains is in a weathered source area. Because it occurs beneath a suspected pre-Illinois Episode diamicton, it would represent an interglacial prior to the Yarmouth episode interglacial and at least one pre-Illinois Episode glaciation. These tentative interpretations are discussed in later sections of the guidebook.

Cores from near the eastern margin of the bedrock valley of the AMV indicate that the valley's fluvial surface aggraded as the earliest Illinois Episode glacier advanced into central Illinois. This early Illinois Episode fill overlies the Sankoty Sand Member or pre-Illinois Episode diamicton and has a maximum surface elevation of 155 m (510 ft) in the Schoepke No. 1 core (Plate 2), where the deposit is 30 m (100 ft) thick and buried by an early Illinois Episode diamicton that we have assigned to the Kellerville Member.

During retreat phases of each of the three Illinois Episode glacial advances, the glacier margin retreated to a position somewhere east of the AMV, meltwater cut a new valley, and that valley was filled with sediment to an elevation higher than that attained during the previous advance/retreat (Fig. 7). This succession of advance-fill-override-retreat-cut events culminated with a high-level fill at an elevation of about 183 m (600 ft) that was buried by the late Illinois Episode Radnor Member diamicton. This surface beneath the Radnor Member is the highest level of fill in the AMV in north-central Illinois. The observed pattern of progressive increase in the elevations of the valley fills from early through middle to late Illinois Episodes might indicate that these three earlier Illinois Episode advances were closely spaced in time and not separated by major periods of incision, like that which occurred during the retreat of the late Illinois Episode and late Wisconsin Episode glaciers. Subsurface data suggest, however, that incision/scour cut deeply into and cut out older Illinois Episode deposits during each of the early-to-middle and middle-to-late Illinois Episode retreats and readvances. Thus, while present evidence indicates that the Illinois Episode glacier retreated east of the AMV (between early-to-middle and middle-to-late) long enough for the AMR to establish, cut, and fill its new course before the next glacier readvance buried the river, available evidence does not answer the question of whether any of these retreats occurred during an intra-Illinois Episode interglacial, such as Lineback (1979b) has suggested occurred between the earliest two Illinois Episode glacial advances.

Upon retreat of the late Illinois Episode glacier that deposited the Radnor Member the AMR incised its valley in central Illinois, establishing a fluvial surface at a very low level (below 145 m (475 ft)) that persisted through the Sangamon Episode. Latest Illinois Episode glacial events in northeastern Illinois related to the deposition of the Winnebago Formation may have had regional impacts on the AM watershed during this latest Illinois Episode time. There is some evidence in Knapp No. 1 core (Plate 2) suggesting renewed aggradation after a post-Radnor incision. During the Sangamon Episode the AMR floodplain elevation was probably lower than 145 m, but little direct evidence of that surface remains. Sangamon Episode deposits from the main stem of the river appear to have been reworked or eroded during the Wisconsin Episode. Measurements of elevations of the Sangamon Episode fluvial surface (Fig. 7) come

from Sangamon Geosols that are developed in fluvial deposits in tributaries to the AMV. These tributary streams were graded to the main river, which flowed at a level below that of the preserved tributary deposits and soils. Thus, the elevations of the Sangamon Geosol in the tributary settings are upper limiting values for the elevation of the AMV surface during the Sangamon Episode.

The valley surface aggraded as the Wisconsin Episode glaciation began and outwash was deposited at progressively higher elevations until the glacier overrode the AMV. When the Wisconsin glacier reached the MIV area and deposited the Tiskilwa Formation, the valley fill had reached levels up to about 163 m (535 ft). At that time, drainage was blocked for a period of time sufficient for the AMR to cut through a divide in Rock Island County and establish its present valley in western Illinois. Major incision does not appear to have occurred during the retreat-readvance between deposition of the Tiskilwa Formation and the overlying Batestown Member or between the Batestown and Yorkville Members. Upon last retreat of the Wisconsin Episode glacier from the MIV area, the Illinois River incised deeply, occupying part of the former course of the AMR. Retreat of the Wisconsin Episode glacier into northeastern Illinois was accompanied by major floods that cut and built significant terraces at elevations between 170 m (560 ft) and 152 m (500 ft) in the MIV. At the end of the Wisconsin Episode, the Illinois River was left at a low elevation near its modern level of 137 m (450 ft).

FIELD TRIP STOP DESCRIPTIONS - DAY 1

Stop 1-1: Clear Creek Section

Wisconsin Episode Succession in Ancient Mississippi Valley East of the Illinois River

Ardith Hansel, Andy Stumpf, and Don McKay

Note: This exposure is steep and there is a hazard of falling rocks.

Objective

To examine a Wisconsin Episode valley fill in part of the Ancient Mississippi Valley.

Topics for discussion at the Clear Creek Section:

1) processes of till formation and deposition,
2) the influence of buried valleys on sedimentation and subglacial drainage, and
3) problems associated with radiometric dating of events on the basis of samples of detrital organic material.

Introduction

The Clear Creek Section exposes about 32 m (105 ft) of Quaternary sediment in a steep, north-facing stream cut (Plate 3) along the south side of Clear Creek, a westward flowing tributary of the Illinois River. The Clear Creek succession has been visited and studied by Survey scientists for over 50 years, but it wasn't until the Illinois Route 29 mapping project that its relation to the Ancient Mississippi Valley was revealed. It was first described in 1953 by Leland Horberg, who interpreted all but the uppermost 6 meters of the succession to be pre-Wisconsin in age. The section was revisited by Horberg and John Kempton in 1959, who sampled it for clay mineral analysis. Murray McComas described the section in his MS thesis (1969); he considered only the lower one-third of the section to be older than the Wisconsin Episode. Horberg (1953), Horberg and Kempton (field notes, 1959), and McComas (1969) all reported the Sankoty sand at the base of the section.

In the late 1980s, W. Hilton Johnson, Leon Follmer, and Ardith Hansel first visited the section as part of a regional stratigraphic study with Mark Kerasotes, who included a description of the section in his MS thesis (1989). Johnson and Hansel revisited the section many times in the 1990s for NSF- sponsored research (Grant EAR-9204838) on till genesis and ice sheet dynamics of the Lake Michigan lobe. Basal Wisconsin tills (Tiskilwa and Batestown, Fig. 1-1A) and deformed substrate materials were well exposed in the lower part of the section at that time.

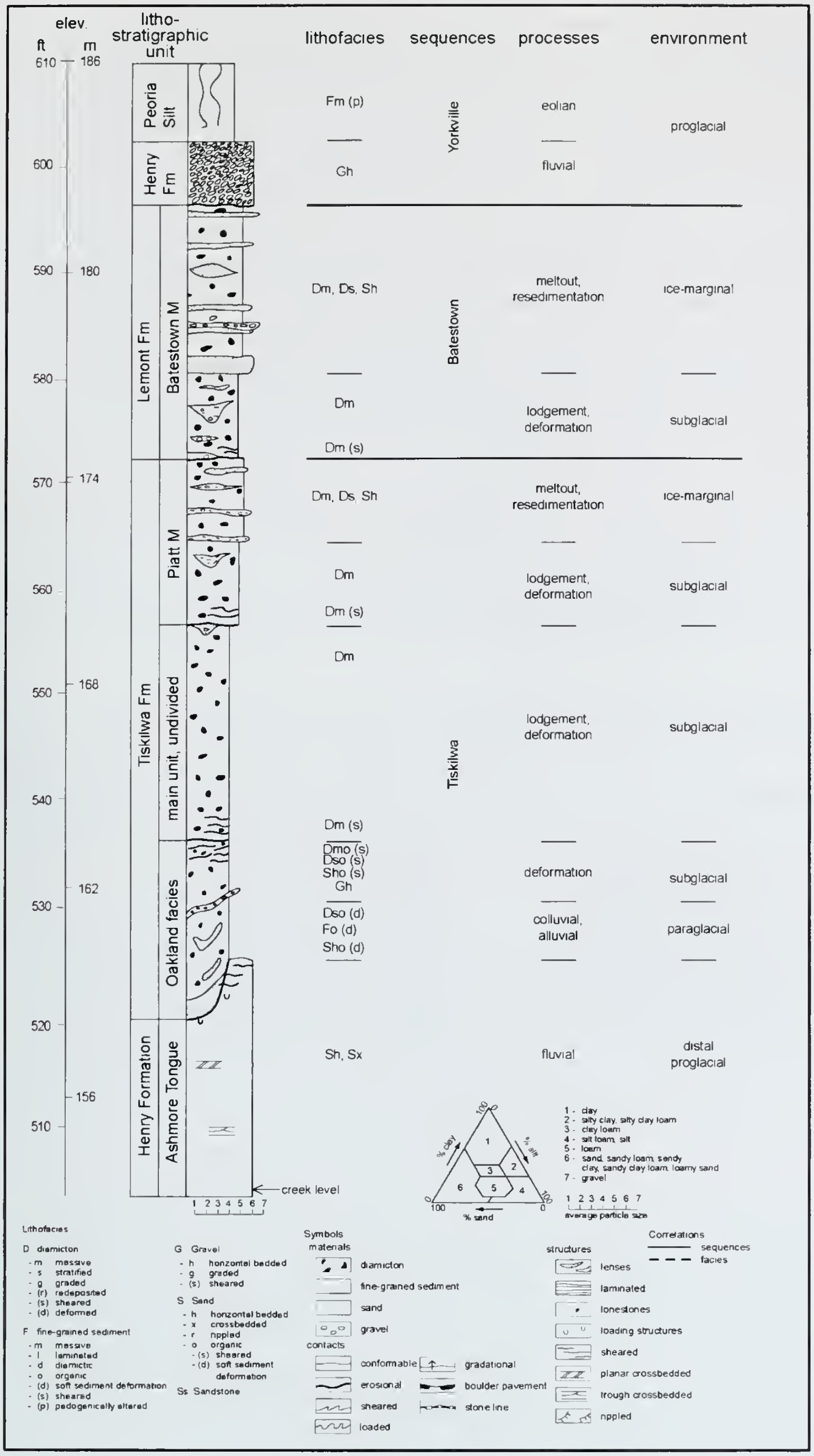


Figure 1-1A. Composite lithofacies and interpreted sequences, processes, and glacial environments for the Clear Creek Section. Modified from Hansel et al. (2003).

On the basis of the similarities of the glacigenic sequences at Clear Creek to those at the Wedron Section and other nearby localities, Hansel et al. (1993) correlated all the glacial sediments at the main Clear Creek Section with those of the Wisconsin Episode. The age of the tills at the section remained controversial, however, because wood dated from within what was interpreted to be basal Wisconsin Episode till (Tiskilwa Formation) did not yield finite radiocarbon ages (e.g., samples I-2099 and I-2221, >40,500 and >42,100 ^{14}C yr BP, respectively). For this reason and because of concern by our colleagues that the glacial succession exposed at Clear Creek was at a much lower elevation than “typical Wisconsin Episode sediments” in the area, the stratigraphically controversial Clear Creek Section was not included as a reference section for the Wisconsin Episode deposits in the lithostratigraphic framework of Hansel and Johnson (1996).

Even so, based on regional lithostratigraphic correlations, Hansel and Johnson interpreted the succession at Clear Creek to be proglacial valley train, colluvial sediment, till intertongued with proglacial meltwater sediment associated with multiple advances, and loess deposited in a pre-late Wisconsin valley during the Wisconsin Episode. From 1992 through 1996, they took a number of geologists to the site to discuss subglacial sedimentation processes and the significance of such features as 1) erosion surfaces at the base of till beds (Fig.1-1B), 2) channel-shaped deposits (Fig. 1-1C) and pebble lags (Fig. 1-1D) between till beds, 3) folded contacts at the base of till beds (Fig. 1-1E, F), 4) poorly homogenized to well-homogenized till locally containing intact gastropod shells, 5) attenuated (and in places folded and faulted) lenses of substrate materials within till (Fig. 1-1G), and 6) locally, deformed substrate materials (Fig. 1-1H). Dave Voorhees, working with Johnson and Hansel, found microfabric evidence for deformation to high strain (Fig. 1-1I), and Hansel measured strong pebble fabrics within parts of the basal till (Table 1-1). Hansel et al. (1993) suggested that basal till (Tiskilwa and Batestown) at Clear Creek was deposited beneath active ice, in part by enfolding of substrate material at the base of a deforming bed. Unfortunately, today slump covers most of the basal part of the section where those features were observed, although we can still observe some poorly homogenized till on the east side of the main section.

Table 1-1. Pebble fabric data by lithostratigraphic unit at the Clear Creek Section.

ID	S[1]	Azimuth	Dip	Material	Lithostratigraphic unit
AKH1	0.662	23°	14°	heterogeneous diamicton	Oakland facies, Tiskilwa Fm
AKH2	0.893	0	13	green diamicton lamina	Oakland facies, Tiskilwa Fm
AKH3	0.840	70	20	wood clasts in diamicton	Oakland facies, Tiskilwa Fm
AKH4	0.537	23	3	heterogeneous diamicton	Oakland facies, Tiskilwa Fm
AKH5	0.939	48°	4°	homogeneous diamicton	Delavan M, Tiskilwa Fm
AKH6	0.924	59°	7°	homogeneous diamicton	Delavan M, Tiskilwa Fm
AKH7	0.868	61°	9°	homogeneous diamicton	Tiskilwa Fm, main
AKH8	0.860	56	15	homogeneous diamicton	Batestown M, Lemont Fm

Description/Discussion

In 2002, we studied the Clear Creek Section in conjunction with the Illinois Route 29 mapping project and in preparation for an INQUA 2003 fieldtrip (Stop 2 in Patterson et al. 2003). Figure 1-1A, a composite sketch for the section, is based largely on our study and earlier observations for till beds in the Tiskilwa and Batestown sequences recorded in the field notes and photographs of W. H. Johnson, A.K. Hansel, and D. Voorhees. Drilling and stratigraphic study as part of the Illinois Route 29 mapping project allowed us to better understand the Clear Creek succession in the regional context of its setting with respect to the Ancient Mississippi Valley. Analytical data for the Clear Creek section are in Appendix B, Table B1-1.

The sand at the base of the section (Ashmore Tongue of the Henry Formation) is interpreted to be a distal, valley-train deposit of the Ancient Mississippi River, which flowed from Rock Island east to Princeton and then south to St. Louis before it was

diverted about 20,000 ^{14}C years ago to its present course along the western border of Illinois (Glass et al. 1964; McKay 1979; Grimley et al. 1998; Curry 1998). Overlying the sand is organic-rich, poorly to well-homogenized diamicton (Fig. 1-1G) containing deformed stratified sediment, lenses of older diamicton, abundant wood, and locally gastropods, some of which appear intact. This organic-rich, in most places poorly homogenized, diamicton (Oakland facies) is not uncommon within 80 kilometers (50 miles) of the late Wisconsin ice margin, particularly in lowland positions. It is attributed to incorporation of organic-rich material (Farmdale Geosol and Robein Member, Roxana Silt) that the late Wisconsin Lake Michigan ice lobe overrode. Locally along its lower erosional contact, the Oakland facies is folded with the Ashmore sand (Fig. 1-1E). Some of the Oakland facies appears to contain or be intertongued with an organic-rich silt derived from the Farmdale Geosol (Robein Member, Roxana Silt), which ranges from about >40,000 to 20,000 ^{14}C years before present. *How did the Oakland facies diamicton form? What makes diamicton containing a variety of inclusions of substrate materials till as opposed to deformed substrate?*

In 2002, we collected and dated three samples (I-5264, I-5268, I-5269) of organic material from diamicton and sorted sediment of the Oakland facies at Clear Creek. Sample I-5268 yielded a finite radiocarbon age (41,010 ±970 ^{14}C yr BP) for wood and led us to conclude that the till succession was indeed from the last glacial episode and the abundant wood in the basal part of the sequence reflected paraglacial and subglacial reworking of substrate material that the Lake Michigan lobe overrode. The radiocarbon ages for wood in the Tiskilwa till at the Friday 3 Section (provided by Carlson et al., Stop 1-2) also are consistent with a Wisconsin Episode age. *What can radiocarbon ages on detrital organic material tell us and what can they not tell us?*

Overlying the organic-rich Oakland facies are three lithologically distinct till beds of the Tiskilwa Formation (Fig 1-1H). Locally, less than 1 meter of gray (lower bed) Delavan till is present. The reddish gray, main Tiskilwa till is overlain by a grayer and less clayey, more-illitic (upper bed) Piatt till. Each till bed of the Tiskilwa sequence has an erosional lower contact and attenuated lenses of lower units are not uncommon in the basal part of each unit (Fig. 1-1B). The contacts are locally marked by truncated channel-fill deposits or pebble concentrations (Fig. 1-1C, D). *How were these lithologically distinct till beds deposited?*

Multiple beds of till and sorted sediment of the Batestown sequence overlie the Tiskilwa sequence (Fig. 1-1A). Rarely have these sediments been accessible for detailed study. Enfolding of the Batestown till and sand in the basal part of the sequence was studied by Johnson and Hansel in 1995 (Fig. 1-1F). The gravel near the top of the section likely represents proglacial fluvial sediment associated with the Yorkville sequence. In the upper part of the second gully east of the main section, clayey (Yorkville) till and ice marginal sediment overlying the Batestown sequence was reported in the field notes of W. H. Johnson taken in 1993. Up to two meters of loess caps the section.

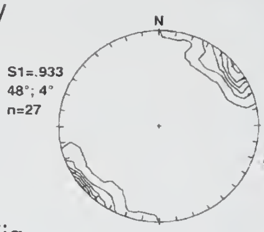


Figure 1-1B. Lithologically distinct till beds (main and lower) of the Tiskilwa sequence (Fig. 1-1A) showing erosional basal contacts and highly attenuated lenses of substrate materials. In general, diamicton homogeneity increases upward within beds. Pebble fabric measured in the lower till bed shows strong orientation of pebbles parallel to regional ice flow from the northeast.

Figure 1-1C. Channel-fill deposit at the base of erosional contact between lithologically distinct till beds (upper and main) of the Tiskilwa sequence.

Figure 1-1D. Pebble lag at erosional contact between lithologically distinct till beds (upper and main) of the Tiskilwa sequence.

Figure 1-1E. Folded basal contact of Tiskilwa sequence till (Oakland facies, Fig. 1-1H) with underlying sand (Ashmore Tongue).

Figure 1-1F. Folded basal contact of Batestown sequence till (Fig. 1-1H) with underlying sand.

Figure 1-1G. Heterogeneous diamicton interpreted to be poorly homogenized till (Oakland facies) in the basal part of the Tiskilwa sequence. This diamicton has a matrix of organic-rich silt loam that contains abundant wood clasts and folded and attenuated laminae of pink and green diamicton and sorted sediment. Hansel et al. (1993) interpreted the laminae to result from enfolding of older diamicton and proglacial substrate materials that were competent enough to maintain some integrity in a subglacial deforming bed.

Figure 1-1H. Lithologically distinct till beds (upper, main, lower) of Tiskilwa sequence showing erosional basal contacts overlying deformed sand (Ashmore Tongue) and diamicton (Oakland facies).

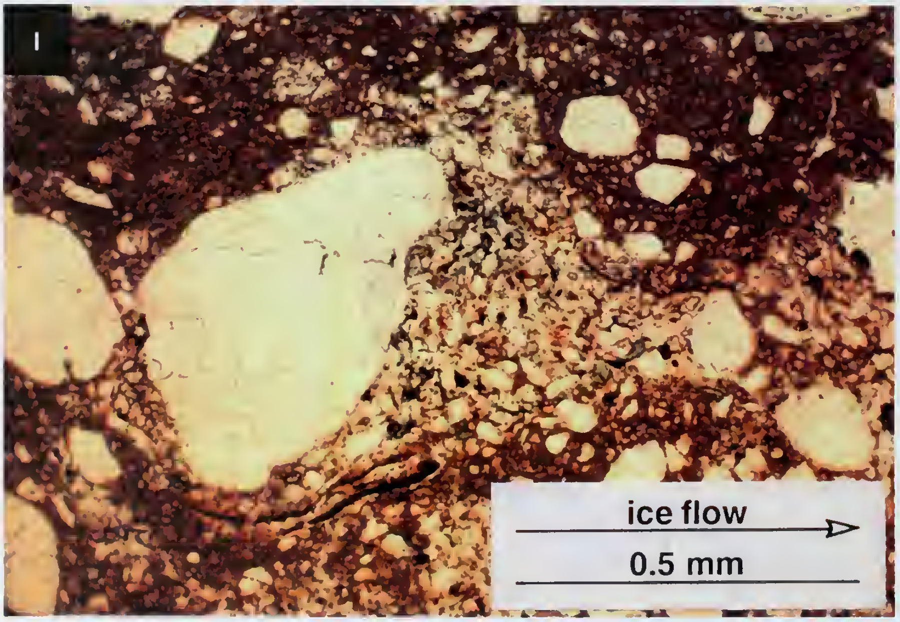


Figure 1-1I. Photomicrograph (plane-polarized light) showing a concentration of silt grains in the lee of a sand grain within an attenuated pink, clayey diamicton lamina within the Oakland facies (Fig. 1-1G). Provided by Dave Voorhees.

Stop 1-2: Friday3 Section

Wisconsin Episode Succession in Ancient Mississippi Valley East of the Illinois River

Andy Stumpf, Ardith Hansel, and Brandon Curry with contributions from Anders Carlson, John Jenson, Peter Clark, and Jason Thomason

Objective

To examine a Wisconsin Episode valley fill in part of the Ancient Mississippi Valley that contains a tongue of proglacial lake sediment and organic material between tills of the Tiskilwa and Batestown sequences (Fig.1-2A).

Introduction

The Friday3 Section is located along a tributary of Clear Creek, southwest of Stop 1-1. The exposure occurs in a high cut bank on a south-facing meander of the stream. The lower half of the exposure is the most readily accessible, and its base lies at an elevation of 158 m (520 ft), which is about 42 m (138 ft) above the bedrock surface in the AMV. This stop offers another opportunity to examine the Tiskilwa and Batestown tills exposed at Stop 1-1, but here these units are separated by a tongue of proglacial lake sediment.

Description

At the base of the Friday3 is a gray to reddish brown, loam to clay loam diamicton (Tiskilwa till) from 5 to 8 m (15 to 25 ft) thick (Fig. 1-2A). The red hue is a distinguishing feature of the Tiskilwa Formation. The diamicton ranges from dense to very dense and has iron staining on fractures and joint faces. The lower 2 m (7 ft) of the diamicton is darker gray, siltier and organic-rich (called the Oakland facies). Throughout the diamicton are scattered, intact terrestrial shells and pieces of wood. The wood fragments are more abundant in the lower part of the section and are aligned in the direction of regional glacier flow (i.e. from northeast to southwest). Macrofabric data from the diamicton also indicate a dominant northeast to southwest flow direction. The diamicton in the upper 1 m (3 ft) is sandier, looser and weakly stratified (Piatt Member).

Radiocarbon dating of wood from the diamicton collected by Anders Carlson and colleagues (see Sidebar 1) yielded ages between 31,400 ^{14}C yr BP and >49,900 ^{14}C yr BP with a general trend of decreasing age up section. These ages are similar to radiocarbon ages obtained on organic material for Tiskilwa Formation diamicton at Clear Creek (Stop 1-1 discussion) and at other sites in the region (Hansel and Johnson 1996).

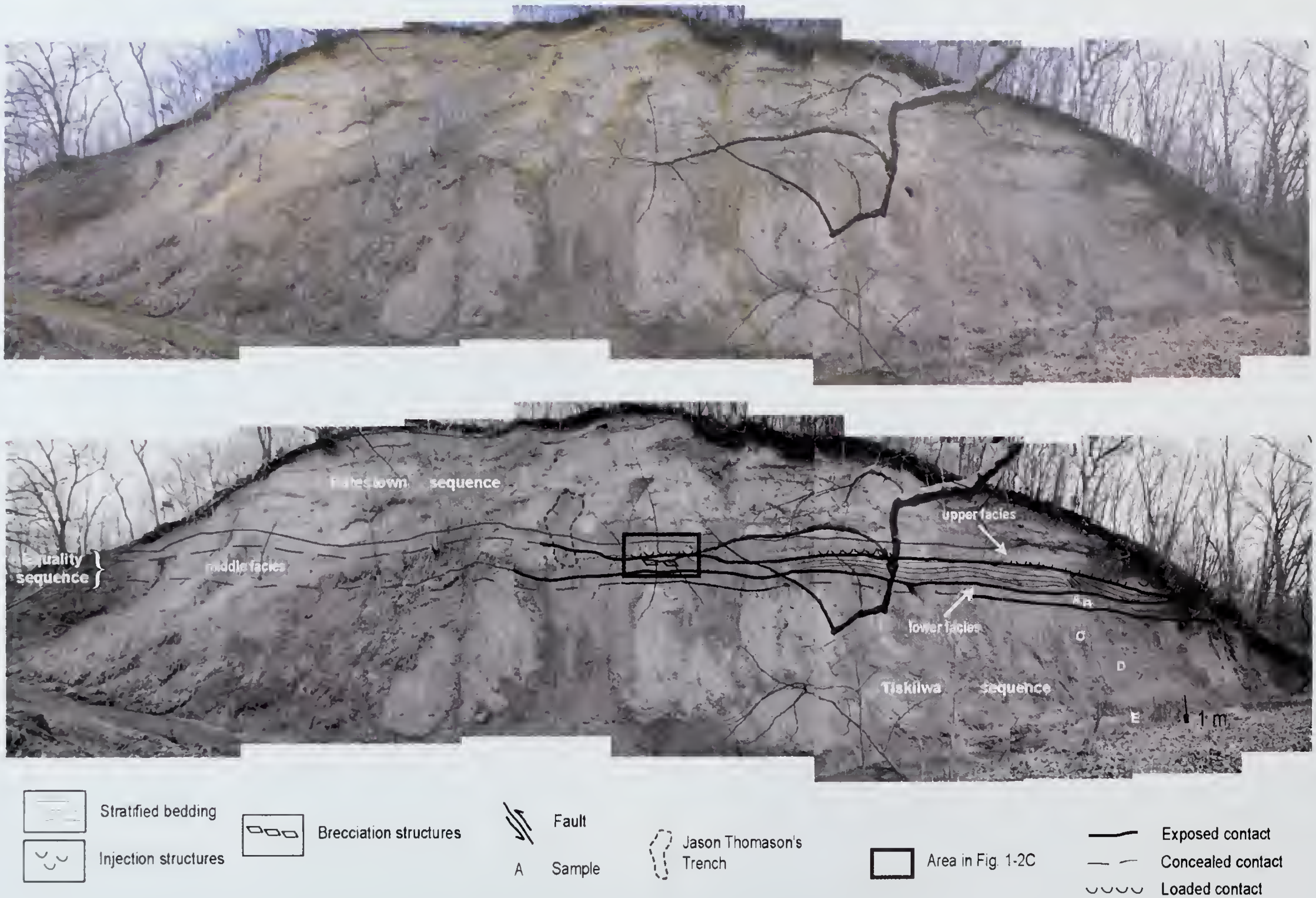


Figure 1-2A: Photomosaic of the Friday3 Section, NW¼, SE¼, NW¼, Sec. 19, T31N, R1W, Putnam Co., IL, based on 2005 photos. Some stratigraphic units are indicated. Sequence boundaries are blue. Photos and mosaic by A.J. Stumpf.

Sidebar 1: Till genesis study for the Tiskilwa till

Anders Carlson[1], John Jenson[2], and Peter Clark[1]

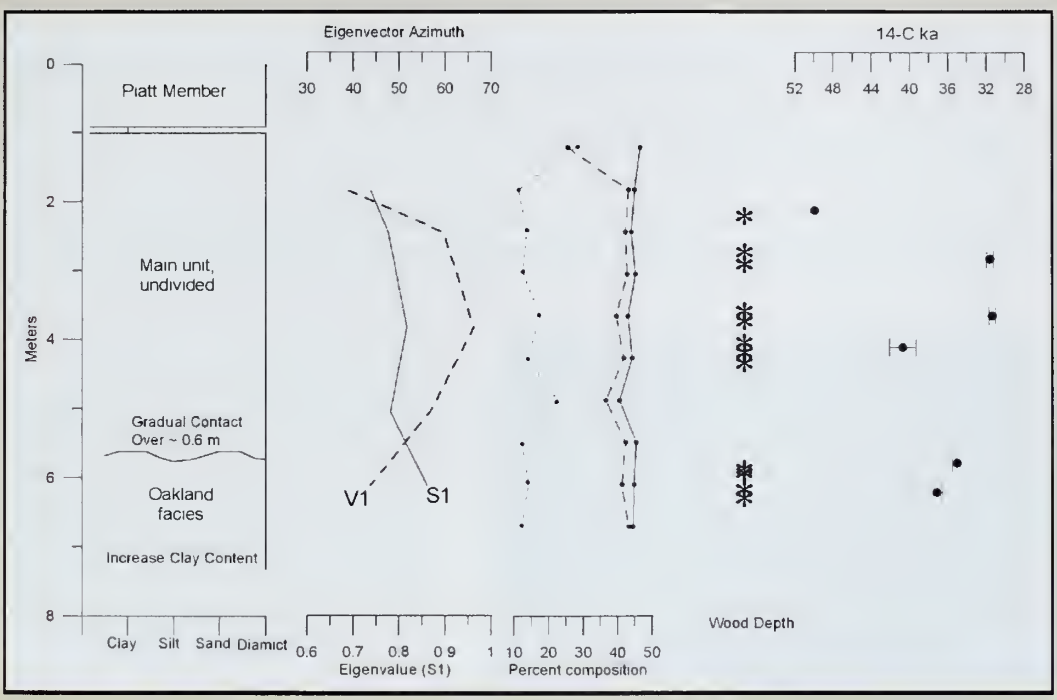
We described and sampled two exposures of Tiskilwa till in Putnam County, IL: the Friday3 (F3) and Clear Creek (CC) sections. Samples were collected for grain-size analysis every 0.6 m. Macro fabric was measured every meter and samples for thin sections were collected at the same locations. Here, we discuss the F3 section supplemented with information from the CC section.

The Tiskilwa till is a reddish-brown, massive, homogeneous, fine-grained diamicton that is 5 to 6 m thick in the study area (see Figure). It overlies the gray, more heterogeneous Delavan till with an ~0.6 m gradational contact. Thin sections from the base of the Tiskilwa till reveal small (<0.5 cm) inclusions of Delavan till in the Tiskilwa till matrix. At the CC section, the base of the Delavan Till grades into underlying proglacial sediment. The tan Piatt till overlies Tiskilwa till at both sections either with an abrupt contact or separated by a 10 to 20 cm thick layer of sorted sediment. The Tiskilwa till has a uniform grain size throughout the sections averaging 45% sand, 39% silt, 16% clay. The Delavan till is slightly siltier averaging 45% sand, 42% silt, 13% clay (see figure). At the CC section, sand inclusions in the Tiskilwa and Delavan tills are up to 1 m thick, have abrupt contacts with the surrounding till and are deformed in the direction of ice flow. Some inclusions contain balls of Tiskilwa till within the sand and have diapirs of till rising into the sand.

Macrofabric is strong throughout the Tiskilwa till with principle eigenvalues (S1) between 0.74 and 0.85. Thin sections similarly indicate strong alignment of particles in the Tiskilwa till matrix. Principle eigenvectors (V1) of the macro fabrics are consistent with regional ice flow but shift direction upward through the section from N40E to N60E and back to N40E near the top of the Tiskilwa till (see figure).

The consistently strong fabrics suggest that the till underwent a uniform degree of strain throughout its thickness while the shift in eigenvectors may reflect initial thickening and subsequent thinning of the Lake Michigan lobe over the study area, causing a change in ice flow direction. The deformed sand inclusions are likely remnant canals that were incised into the till at the base of the ice and subsequently deformed. The presence of Tiskilwa till balls in the sand indicates that the deposition of the sand post-dates the surrounding till and that the sand was not incorporated into the basal ice and subsequently deposited with the till.

We propose a time-transgressive depositional model for the Delavan and Tiskilwa tills. Ice advance incorporated local proglacial sediment into the basal Delavan till. This till isolated the heterogeneous proglacial sediment from the ice base and allowed the deposition of the more homogeneous Tiskilwa till. The deformed sand inclusions and gradational contacts between the Tiskilwa and Delavan tills and the underlying sediment imply a deforming bed mechanism of transport and deposition. However, the preservation of the shifting macro fabric orientation indicates that this deforming layer was less than 1 m thick. If the till was actively deforming to a greater depth, then earlier ice flow directions recorded by the macro fabric would be erased by later ice shifts in flow direction during maximum extent and retreat. The



Friday3 section. From left to right Till unit thicknesses Eigenvalues and eigenvectors (eigenvalues (S1) are the solid line, eigenvectors (V1) the dashed line) Constituency (percent sand is the solid line, silt the dashed line and clay the dots) Location of wood in the till and radiocarbon ages (the radiocarbon date at 2 1 m is > 49 9 ^{14}C ka)

[1]Department of Geosciences, Oregon State University, Corvallis, OR 97331, [2]WERI, University of Guam, Mangilao, GU 96923

Particle size and clay mineral data obtained for the Tiskilwa Formation diamicton at Friday3 (Appendix B, Table B1-2A) are similar to data collected for this diamicton from other sites in Illinois (e.g., Wickham 1975). Generally, the diamicton decreases in silt content towards the top.

The Tiskilwa Formation diamicton here is overlain by 3–5 m (10–16 ft) of brown to pinkish gray diamicton and clay, silt, and fine sand containing abundant shells and organic material. These fine-grained sediments (here classified as an unnamed tongue of the Equality Formation) are indurated and overconsolidated. Some beds are folded, faulted and/or deformed. The deposit can crudely be subdivided into three facies (Fig. 1-2A): a lower zone containing beds of pebbly diamicton or sand and gravel forming an irregular and transitional contact with the underlying diamicton that grades upward into a massive, organic-rich silt; a middle zone composed predominantly of horizontally bedded very fine- to medium-grained sand with interbeds of silt and clay that are locally deformed or truncated; and an upper zone of laminated to crudely bedded silty marl, very fine- to fine-grained sand, or clay that contains abundant wood, shells, and plant macrofossils.

In the unnamed tongue of the Equality Formation, shells, wood, and other organic material are most common in the upper facies, especially where bedding or laminae in the sediment are more diffuse. Significant concentrations of woody plant detritus are also found in sandier intervals of the laminated sediment. Two samples containing spruce needles and seeds from these intervals returned AMS ages of >48,000 ^{14}C yr BP (CAMS 103615, 103616). The shell and plant macrofossil assemblage contains the remains of aquatic organisms (*Pisdium, Lymnaea palustris)* typically found in a pond-like environment that contained a dense accumulation of vegetation. The assemblage was likely deposited in a cool climate similar to conditions today in the Northern Plains and southern Prairie Provinces of Canada.

Ostracode assemblages in the stratified, gray silt beds of the unnamed tongue of the Equality Formation live today in dilute, bicarbonate-charged waters under cool, relatively dry, continental conditions. The abundance of nektonic/plankonic species relative to benthic species (388:66) suggests relatively shallow standing or very slowly flowing water. Comparison of the four most abundant ostracodes in this assemblage with the North American Non-Marine ostracode database (NANODe; Forester et al. in review) suggests similarity to two lakes in the United States (out of 756

Fig. 1-2B. Lower contact of the Batestown Member diamicton with the underlying unnamed tongue of the Equality Formation. Note the convoluted bedding and deformation of interbeds.

sites). The two lakes, Moose Lake and Mina Lake, occur in Minnesota where precipitation is about three-fourths that of Peoria, Illinois today (roughly 650 vs. 900 mm/yr), and, of course, where winters are longer, drier, and colder. The lakes are relatively dilute (total dissolved solids of 222 to 403 mg/L). A more definitive reconstruction of paleohydrology and paleoclimate would likely result by comparing the Friday3 assemblage with a Canadian database owned by L. Denis Delorme (e.g., Curry and Delorme 2003).

Features consistent with intense deformation were observed in the middle and upper facies, such as isoclinal folding, kink banding, convoluted bedding, and ball and pillow structures (Fig. 1-2B), No shear structures have been observed in these deposits, but only a preliminary investigation has been completed.

Overlying the Equality Formation tongue is a grayish brown, silt loam diamicton (Batestown Member, Lemont Formation). The diamicton ranges from 5–10 m (15–30 ft) thick and contains several broad lenses of sand and gravel (Fig. 1-2A). An abrupt erosional contact marked by a thin, coarsening upward sequence of sand and gravel is mapped at 1–2 m (3–7 ft) below the top of the section. Above the sand and gravel, the diamicton is slightly coarser, contains more beds of sand and gravel, is oxidized, and is fractured. Ring-shear tests conducted by Jason Thomason (Sidebar 2) on samples of the Batestown Member diamicton indicate a polyphase shift in the sense of strain (ice-flow direction).

Discussion

Radiocarbon ages obtained for organic material from this unit indicate that the organic material pre-dates the Wisconsin Episode. As discussed at Stop 1-1, old ages for organic material in the Oakland facies and main Tiskilwa Formation are common. The absence of internal shearing does not support the possibility of the deposit being an entrained block of older organic-rich sediment. Carlson et al. (Sidebar 1) found Wisconsin Episode ages for wood within the Tiskilwa till that underlies this deposit. *Could the organic material be older wood that melted out of the Tiskilwa or Batestown ice and was washed into a small depression in front of the glacier?*

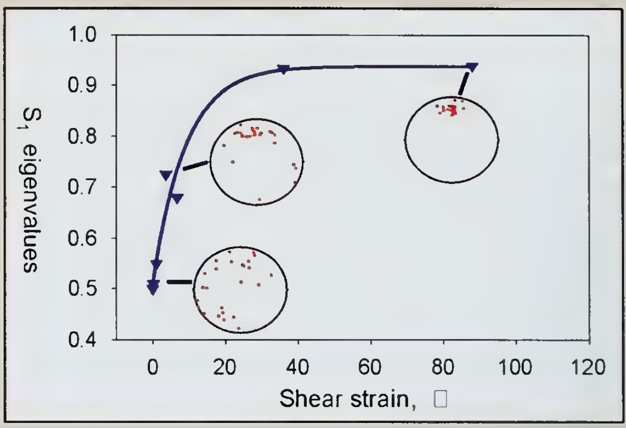
The alignment of wood fragments and stretched shells in the general direction of ice flow parallels the AMS fabrics of Thomason (Sidebar 2). *What subglacial processes allow the preservation of fragile material (i.e. shells, wood, plant macrofossils) in diamictons and lake sediment?*

Sidebar 2: Till genesis study for the Batestown till

Jason Thomason, Iowa State University

Landscapes formed by southern lobes of the Laurentide Ice Sheet have frequently been associated with deformation of subglacial sediments. However, the degree to which those sediments (commonly till) have been sheared has never been quantified. Using a large ring-shear device, a basal till of the Lake Michigan Lobe (LML) (Batestown member, Lemont Formation) was sheared to different prescribed strains that ranged through nearly three orders of magnitude. Anisotropy of magnetic susceptibility (AMS) analysis was conducted with laboratory samples. The degree of alignment of magnetic particles was quantified by determining the fabric defined by directions of maximum magnetic susceptibility of multiple samples. Laboratory results show that these fabrics become stronger and increasingly parallel to the shearing direction with strain and do not become steady until shear strains of 20–30 (Fig. a). Thus, a proxy for strain has been developed for application to field studies.

Figure a Results of laboratory AMS analyses of sheared Batestown till Microfabric strength (S, eigenvalue) as a function of strain for laboratory experiments Sense of shear for each stereoplot is



Field samples of the Batestown till were taken from the Friday3 section near Henry, Illinois. Intact samples (each 8 cm ^{3}) were extracted at 20 cm intervals (25 samples per interval) along a vertical profile that spanned the entire till thickness (~3.4 m). Magnetic susceptibility analyses have been completed (Fig. b). Based on the laboratory calibrations, field data indicate that significant portions of the Batestown till have been deformed to shear strains of at least 10. Patterns of fabric strength and direction suggest that strain accumulated as the basal till accreted over time rather than during a single deformation event. However, further field work is needed to test this hypothesis.

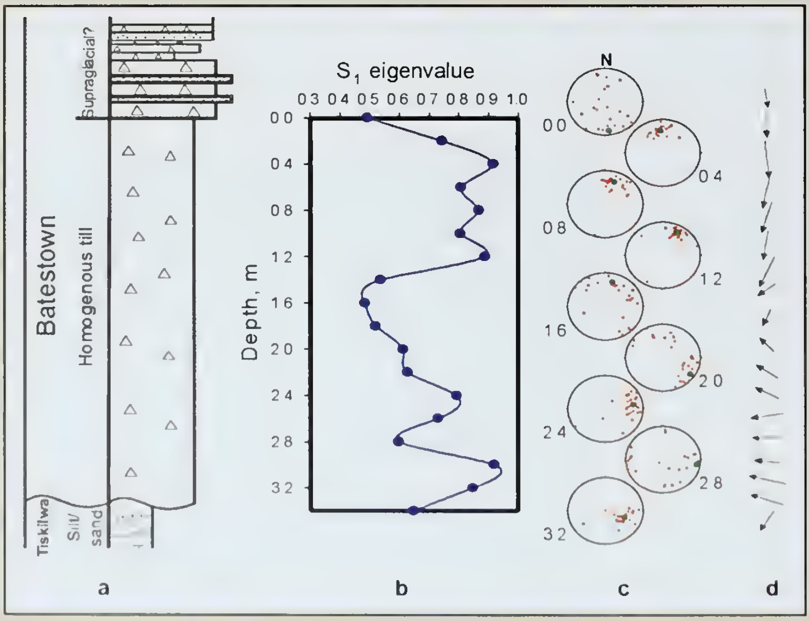


Figure b a) Local stratigraphy of Friday3 section, b) AMS fabric strength (S, eigenvalue) as a function of depth for Batestown till, c) Lower hemisphere stereoplots (every 0 4 m) of directions of maximum susceptibility (the green dot in each plot is the eigenvector direction). d) Vectors of inferred ice-flow direction with depth (the length of each vector is proportional to the AMS fabric

Stops 1-3, 1-4, 1-5, & 1-6: Rattlesnake Hollow (RH) Sections

Wisconsin and Illinois Episode Successions in Bedrock Uplands West of the Illinois River

Don McKay, Dick Berg, and Andy Stumpf

Introduction

The Rattlesnake Hollow Sections provide a relatively well-exposed local example of the geologic units and unconformities that occur throughout the MIV. When discovered early in our work, these sites were assumed to reveal the stratigraphic record in a fairly straightforward way. Detailed work in the hollow has shown that the RH record is not simple. Instead, it is typical of the complexity of the AMV and vicinity. It contains several of the major Quaternary units and is missing several others that are cut out along some significant unconformities.

RH is a short, modern, eastward-flowing tributary of the Illinois River, which is incised in the drift-covered bedrock upland west of the AMV. The valley of RH intersects a bedrock bench set below the level of the local bedrock upland, but having an unknown width and orientation. Exposed are some of the oldest Quaternary deposits known to exist in the area. The low bedrock bench contributed to preservation of older glacial drift by sheltering it from later glacial flows.

We will enter RH about 1.6 km (1 mile) upstream of its mouth and walk eastward about 0.4 km (.25 mi) downstream, making four stops that offer unique opportunities to view some of the Wisconsin Episode deposits and then study the underlying, older Quaternary deposits in several closely spaced exposures (Fig. 1-3A). Data from these sites is given in Appendix B, Tables B1-3, B1-5, and B1-6.

The Lake Michigan lobe glacier advanced into western Illinois at least three times during the Illinois Episode. These ice advances terminated at limits 150, 80, and 30 kilometers (95, 50, and 20 miles) to the west of the AMV. Sediments deposited during these three advances are widespread east and west of the valley and interfinger with the valley fill. It is this interfingering that allows relative dating of glacial and fluvial events.

Rattlesnake Hollow contains exposures of part of this succession. Early and middle Illinois Episode diamictons (Glasford Formation, Kellerville and Hulick Members) are preserved and exposed in RH. Both have lithologies that are typical of these units. Late Illinois Episode diamicton (Glasford Formation, Radnor Member) has not been found in RH but is widespread regionally, extending 20 mi west of the AMV.

The Pike Geosol (Willman and Frye 1970), a weathering profile developed in the early Illinois Episode diamicton (Glasford formation, Kellerville Member), has been cited as evidence of a significant duration for the retreat between the early and middle Illinois Episode diamictons. Evidence for the Pike Geosol has not been found in RH to date.

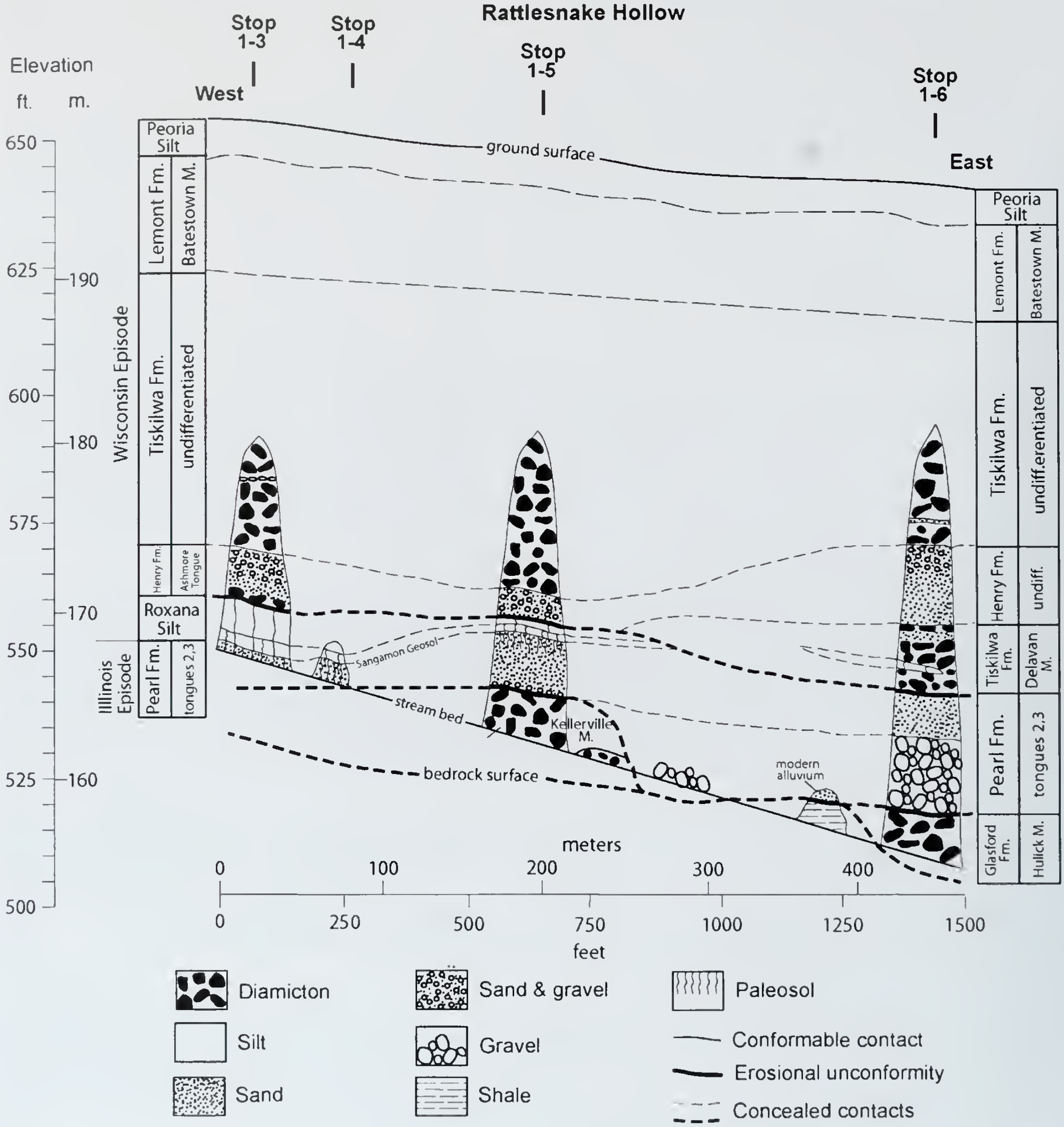


Figure 1-3A. Cross section showing lithofacies and lithostratigraphic correlations between field trip stops 1-3, 1-4, 1-5, and 1-6 in Rattlesnake Hollow, Marshall Co., IL.

Subsurface investigations via drilling in the AMV show that significant thicknesses of fluvial sediments, interpreted to be proglacial, overlie each of the three Illinois Episode diamictons. This indicates that the Illinois Episode glacier retreated east of the AMV after deposition of the each of the diamictons. *How do the Illinois Episode fluvial sediments in RH relate to events in the AMV?*

During final retreat of Illinois Episode ice from the area, the AMR incised a channel east of the RH exposures and remained there throughout the Sangamon Episode and the early to middle Wisconsin Episode. Sangamon Episode deposits have not been recognized in the main stem of the AMV, where fluvial sediments of that age were likely swept from the valley by Wisconsin Episode meltwater. In RH, three well preserved and exposed profiles of the Sangamon Geosol are developed in fluvial sediments. These poorly to moderately drained paleosol profiles may be the best exposed examples in Illinois of the Sangamon Geosol formed in a Sangamon or late Illinois Episode fluvial deposit graded to the AMR. *Can we further narrow the age of those fluvial deposits? What do the characteristics of those deposits suggest about their origin? Are they glaciofluvial or postglacial fluvial in origin? Are they Illinois Episode outwash, AMV fluvial sediment, or Sangamon Episode alluvium. Were they deposited in the AMV or a tributary to the AMV? Were they graded to an alluvial surface in the main valley?*

Wisconsin Episode meltwater entered the AMV as early as 50,000 ^{14}C yr BP, carrying and depositing silt on bars and floodplains that served as the local source of loess (Roxana Silt) blown onto nearby uplands. This early Wisconsin loess is preserved in RH, although in most exposures, it is overconsolidated, deformed, and partially truncated.

When late Wisconsin ice emerged from the Lake Michigan basin, it introduced highly dolomitic outwash into the AM watershed. Yellowish brown to gray, dolomitic Peoria loess was deposited. The Morton Tongue of the Peoria Silt, which underlies the Tiskilwa Formation in most places regionally, is absent in late Wisconsin till. The Morton Tongue is absent from RH. *What does its absence indicate about the thickness of material eroded?*

Just before 20,000 ^{14}C yr BP, the Wisconsin Episode glacier reached and overrode the AMV and RH, depositing the diamictons that form the upper 30 m (100 ft) of the local glacial succession. The lower part of those units is accessible on our traverse. Both the lower diamicton (grayish brown Delavan Member) and upper diamicton (reddish brown undivided main unit of the Tiskilwa Formation) are present.

We will visit four exposures in Rattlesnake Hollow at stops 1-3, 1-4, 1-5, and 1-6 (west to east) while traversing about 0.4 km (.25 mi) distance and 55 m (180 ft) of elevation.

Objectives

The objectives of visiting the Rattlesnake Hollow exposures are to:

1) examine and discuss the Rattlesnake Hollow deposits that comprise the discontinuously preserved, seldom exposed, middle and lower part of the region's Quaternary stratigraphic succession in the AMV,
2) provide an overview of the succession of Quaternary sediments on the bedrock upland that delineates the western margin of the AMV,
3) consider how fluvial and glacial units and unconformities preserved in the bedrock upland correlate to units and events in the adjacent AMV,
4) identify principal marker beds (Sangamon Geosol and Roxana Silt) and consider evidence of significant erosion at some sites.

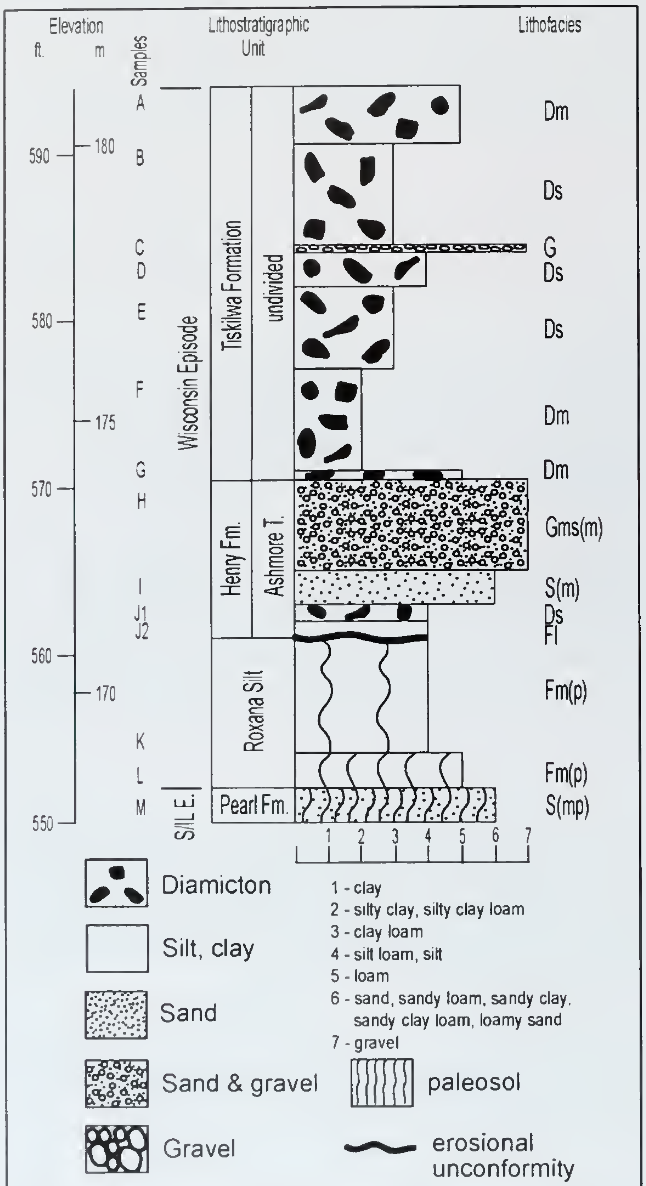


Figure 1-3B. Lithostratigraphy and lithofacies interpretation for deposits exposed at Stop 1-3 in Rattlesnake Hollow, Marshall Co., IL.

Stop 1-3: Rattlesnake Hollow West-A Section

Setting

Stop 1-3 is a large cut on the north bank of the stream that exposes the upper part of the glacial succession in Rattlesnake Hollow.

General Description

At the base of the exposure is the upper solum of a strongly developed paleosol (Fig. 1-3B). Exposed are about 60 cm (2 ft) of strong brown, noncalcareous sandy loam. This Bt horizon is overlain by about 60 cm (2 ft) of sandy silt with upper solum characteristics. Digging to remove surface oxidation reveals these units to be reduced. The soil developed under poor drainage conditions in sandy parent material. The profile is a Sangamon Geosol, developed in coarse stratified sediments of Sangamon or Illinois Episode age.

Conformably overlying the upper solum of the paleosol is 2.1 m (7 ft) of compact, leached to weakly calcareous, reddish-brown silt loam that we interpret to be loess, the Wisconsin Episode Roxana Silt. The source of this loess was the AMV east of this location. With a thickness of 2.1 m (7 ft) here, this

occurrence of Roxana Silt is the thickest observed in the area, suggesting that this site was near the loess source.

Overlying the Roxana unconformably, is massive, medium to coarse grained sand (Ashmore Tongue of the Henry Formation), which includes thin beds of diamicton near the base. Its upper contact is marked by a change in slope and deeper gullying on the surface of the outcrop. These sediments are proglacial outwash and sediment flows deposited locally in front of the advancing Wisconsin Episode glacier.

The upper 8 m (25 ft) of the section is composed of reddish-brown, loam-textured diamicton (Tiskilwa Formation). This diamicton contains numerous, thin beds of sand and gravel that extend horizontally throughout the unit. A few kilometers to the west, the diamicton composes the Bloomington Morainic System, formed as the Lake Michigan glacial lobe reached its terminus west of the AMV. Considerable evidence of shear deformation is present, involving the lower part of this diamicton, the proglacial fluvial sediment, and the upper part of the underlying loess.

Discussion

The paleosol at the base of the section is the first of three paleosol profiles that we will examine in Rattlesnake Hollow. From evidence at this stop, the age and origin of the sandy parent material are uncertain. We do not know what unit underlies the sands at this site, information that would help narrow the age of the deposit.

These sediments might have been deposited by a high-level AMR or by a stream graded to the AMR to the east. They might also be proglacial fluvial. We have considered several alternative origins: The Sangamon Geosol is developed 1) in fluvial sediments of a Sangamon Episode tributary graded to the AMR to the east, or 2) in late Illinois Episode glacial-fluvial sediment, deposited in a high-level AMR channel during or after retreat of the late Illinois Episode (Radnor) glacier, or 3) in exhumed early or middle Illinois Episode sediment exposed by incision during the Sangamon and/or Illinois Episodes. Regardless of origin of its parent material, poor drainage of the Sangamon Geosol indicates local conditions were wet during its formation, conditions consistent with a lowland setting for the deposit. Based on the information available at stop 1-3, we cannot eliminate any of the three options.

Loess overlying the paleosol is typical of Roxana Silt in mineralogy, texture, and color, but not in density. The compactness of the silt is atypical of the examples of this loess unit that we will see elsewhere on the trip. Other examples also overridden by the Wisconsin glacier are less compact. Sand and gravel above and below the silt here probably facilitated drainage and consolidation of the loess unit during glacial loading. The upper part of the Roxana Silt, including the Farmdale Geosol, is missing, as is the proglacial late Wisconsin loess (Morton Tongue). The latter is a yellowish-brown to gray, calcareous silt that is a distinctive late Wisconsin Episode marker bed. Uneroded Morton Tongue elsewhere is nearly as thick as the Roxana Silt, suggesting that at least 2 m (6.6 ft) of loess was eroded at this site.

Stop 1-4: Rattlesnake Hollow West-B Section

Setting

Site 1-4 is a small stream exposure on the north bank of RH. Its base (stream level) is about 1.5 m (5 ft) lower than the base of stop 1-3. About 3 m (10 ft) of section is exposed.

General Description

Stop 1-4 exposes a complete profile of the Sangamon Geosol that correlates to the unit exposed at the base of Stop 1-3. The lower part of the Roxana Silt conformably overlies the poorly drained paleosol profile developed in a loam-textured parent material. The profile, which has indistinct horizonation, displays a large number of closely spaced, prominent, burrow fillings that are interpreted to be krotovina (crayfish burrows). The filling material is dark-colored, organic, silt loam that was derived from the upper-solum of the profile.

Discussion

Sangamon paleosols, ubiquitous on the Illinoian till plain beyond the Wisconsin Episode glacial margin in west-central Illinois, are commonly preserved beneath the outer 65 to 80 kilometers (40 to 50 miles) of Wisconsin Episode drift in central Illinois. Those preserved profiles represent the range of soil drainage conditions that existed on the low-relief Illinoian till plain where poorly drained soil profiles were common. Poorly drained paleosols commonly developed in sediments accreted by local slopewash into scattered depressions on the generally flat till plain (Frye et al. 1960). In early reports, these soils were called "Illinoian gumbotil" or "accretion gley profiles".

The loamy parent material of the Sangamon Geosol has been modified extensively by pedogenesis. *Is there evidence of its origin? Can slopewash sediment be distinguished from alluvium? Is there evidence to suggest whether the deposit accumulated prior to or during pedogenesis?*

The profile of the paleosol exposed at Stop 1-4 is consistent with an interglacial (Sangamon) soil developed in alluvium in a wet lowland setting. Saturated conditions required by crayfish prevailed on the local low landscape position. Gradual alluvial sedimentation is indicated by the thickened upper solum and indistinct horizonation. The occurrence of glacial-fluvial sand deposits in the vicinity (see site 1-5) suggests that the parent material may include in situ Illinois Episode outwash reworked by an interglacial stream.

Stop 1-5: Rattlesnake Hollow Middle Section

Setting

Downstream in Rattlesnake Hollow we arrive at the third of four outcrops. Stream level at this stop (1-5) is about 5.5 m (18 ft) lower than our first RH stop (1-3). Stop 1-5 is a large stream cut on the south side of the valley.

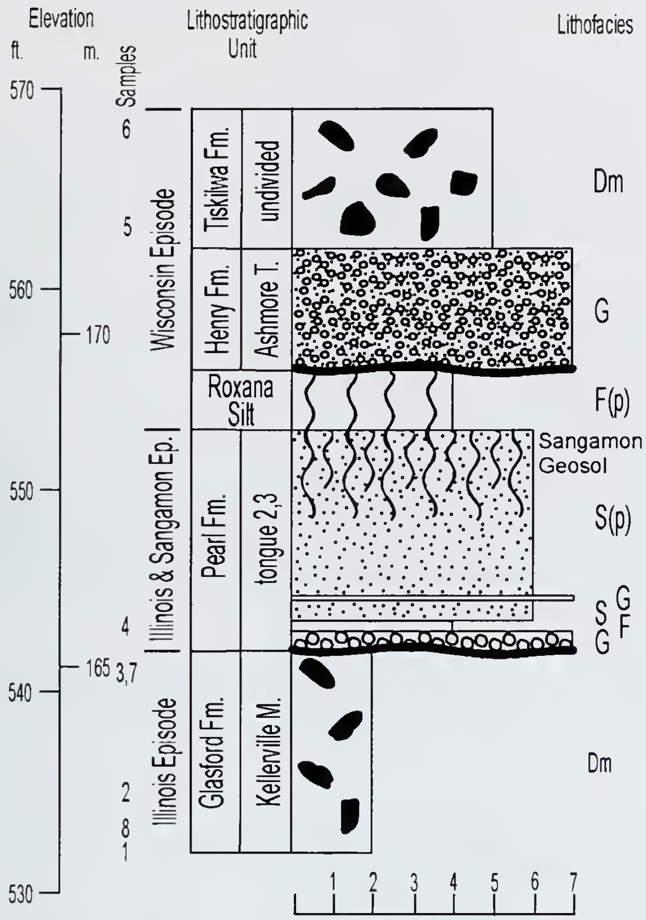


Figure 1-5. Lithostratigraphy and lithofacies interpretation for deposits exposed at Stop 1-5 in Rattlesnake Hollow, Marshall Co., IL.

General Description

At the base of the outcrop, 3.3 m (10 ft) of gray, calcareous, pebbly, silty clay loam diamicton contains scattered wood and coal fragments and a few gastropod shells (Fig. 1-5). Its matrix texture averages 15 percent sand, 49 percent silt, and 36 percent clay (Appendix B, Table B1-5). Its clay fraction contains subequal amounts of expandable clay minerals and illite, averaging 40 percent of each. The unit contains much more dolomite than calcite. These characteristics are consistent with those of the regionally mapped early Illinois Episode, Lake Michigan glacial lobe diamicton (Kellerville Member), which can be found as far west as eastern Iowa.

Unconformably overlying the basal diamicton is 3.4 m (11 ft) of gravel, silt, and sand. The moderately drained profile of the Sangamon Geosol is developed in the upper part of this unit. Missing from the succession are the middle and upper Illinois Episode diamictons (Hulick and Radnor Members). The Sangamon Geosol is conformably overlain by 1 m (3 ft) of reddish brown, non-calcareous, silt loam, the Roxana Silt. As at the first RH stop, the Morton Tongue is absent.

The Roxana silt is unconformably overlain by 1.8 m (6 ft) of calcareous gravel and the thick Wisconsin Episode diamicton succession. Only the base of the diamicton is accessible easily.

Discussion

The mineralogy and clast content of the diamicton in the early Illinois Episode Kellerville Member reflects incorporation of substrate materials along the flow path followed by the glacier as it flowed southwestward across Illinois. Along that path, the glacier overrode and entrained the highly weathered, expandable-clay-mineral-rich profile of the Yarmouth Geosol developed primarily in pre-Illinois Episode till. It also incorporated dolomite from the Niagaran dolomite bedrock that rims Lake Michigan and Pennsylvanian rocks that are mainly illite-rich shale. Thus, the diamicton is a silty, clayey, expandable-clay-mineral rich deposit that contains more dolomite than calcite.

The early Illinois Episode glacier eroded Pennsylvanian rock locally, as indicated by common coal and shale clasts in the diamicton. Gastropods, intact in the diamicton at Stop 1-5, were probably transported only a short distance before deposition and may have come from alluvial sediments eroded from the nearby AMV analogous to those seen at Stop 1-2 (Friday3).

Based on evidence at Stop 1-5, the stratified succession above the Kellerville Member can be interpreted as middle or late Illinois and/or Sangamon Episode fluvial sediment that fills a channel incised in Illinois Episode deposits. The missing middle and late Illinois Episode diamictons may have been eroded during this fluvial event. The configuration of the bedrock surface is poorly known, so we are uncertain whether these fluvial deposits are part of the fill of a local tributary to the AMV or deposits of the AMR on a bedrock bench near the western edge of the valley. In any case, the intermediate drainage class of the Sangamon Geosol reflects drainage into the underlying sands and suggests that this site was located somewhat above the floor of the valley.

Like Stop 1-3, at Stop 1-5, loess of the Morton Tongue (Peoria Silt) is missing. Its absence highlights the vulnerability of loess deposits to erosion during glacial overriding.

Stop 1-6: Rattlesnake Hollow East Section

Setting

In the walk from stop 1-5 to 1-6, note that the small exposures of the diamicton (Kellerville Member) in the modern stream bed give way to a concentration of large boulders. *What is the source of these and why are they common in this reach of the stream?*

At the last cut bank before Stop 1-6, Pennsylvanian shale is exposed and overlain by postglacial alluvium. A short distance downstream at Stop 1-6, bedrock is not exposed.

Stop 1-6 is a large stream cut on the south side of Rattlesnake Hollow, exposing 25 m (81 ft) of Quaternary deposits. Its base is at an elevation of about 156 m (513 ft), more

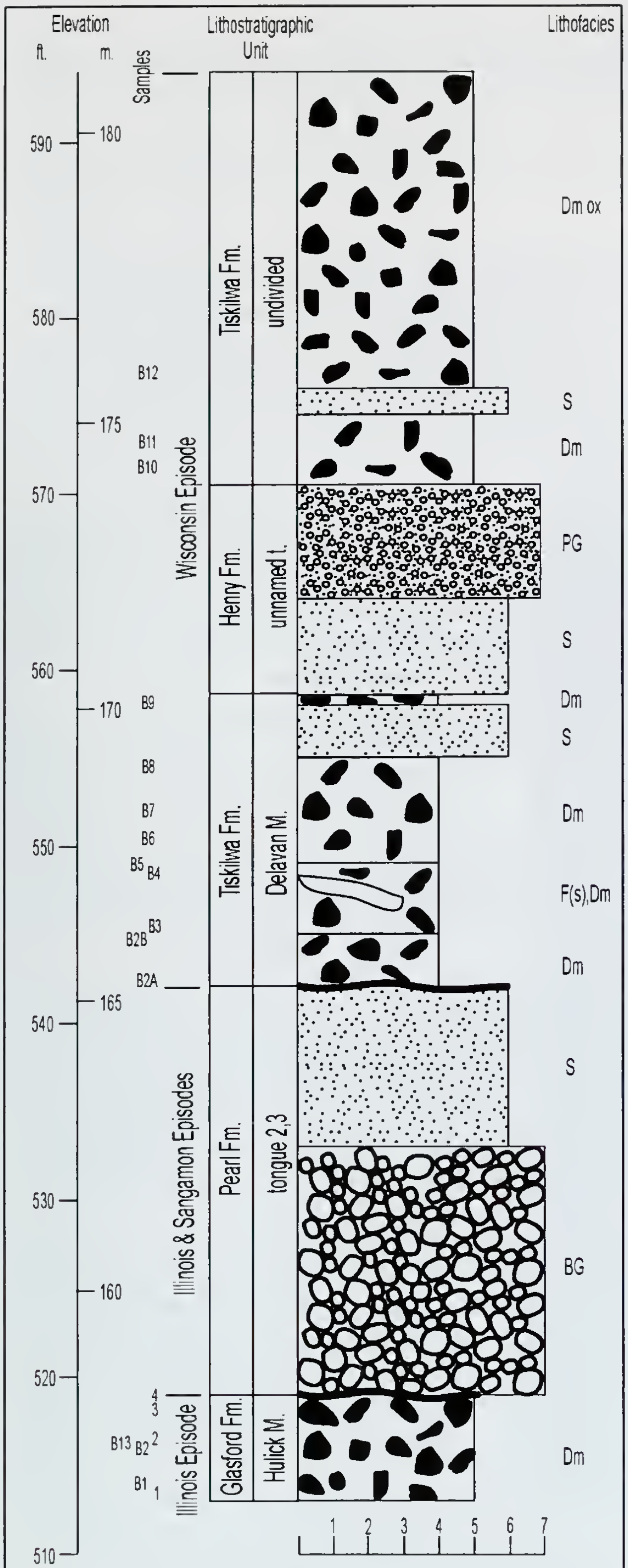


Figure 1-6A. Lithostratigraphy and lithofacies interpretation for deposits exposed at Stop 1-6 in Rattlesnake Hollow, Marshall Co., IL.

than 11 m (37 ft) lower than the base of Stop 1-3. Stop 1-6 exposes more of the Illinois Episode deposits than the other stops and some units not previously seen.

General Description

At stream level, a 1.9 m (6.1 ft)-thick dark grayish brown, calcareous, loam-textured diamicton is exposed (Fig 1-6A). Its texture averages 40 percent sand, 43 percent silt, and 17 percent clay. It contains a large amount of illite (67 percent) and a relatively low amount of expandables (11 percent) in its clay fraction. It contains significantly more dolomite than calcite.

Overlying the stream-level diamicton is a succession of coarse stratified sediments including, at the base, 4 m (14 ft) of very poorly sorted, massive, boulder gravel with rounded to angular clasts of both local (limestone and shale) and erratic lithologies up to 60 cm (2 ft) in diameter in a matrix of calcareous coarse sand. The boulder gravel is overlain by 2.7 m (9 ft) of poorly sorted, calcareous, medium to coarse sand and fine gravel.

Diamicton, 4 m (13 ft) thick, dark grayish brown, calcareous, and silt loam to silty clay loam in texture, overlies the sand and gravel on an abrupt planar contact that shows evidence of shear. Included within the diamicton are attenuated beds and lenses of reddish brown silt loam that resemble the Roxana Silt, seen in stops 1-3, 1-4, and 1-5.

Sand and gravel, 4.75 m (15.5 ft) thick, overlies the diamicton unit and includes a 15 cm (0.5 ft) diamicton 1 m (3 ft) above its base. The unit coarsens from medium and coarse sand at the base to pea gravel in its middle and upper parts.

Brown to reddish brown, loam-textured, calcareous diamicton more than 7 m (23.5 ft) thick is exposed at the top of the outcrop.

Discussion

The stream-level diamicton at stop 1-6 is not the same unit as that exposed at the base of the last stop (1-5). Despite being considerably lower in elevation, it is a unit that stratigraphically overlies the lowermost diamicton at Stop 1-5. The lithologies and mineralogies of the stream-level diamictons at stops 1-5 and 1-6 differ markedly. Table 1-6 shows the average texture and clay mineralogy of the Illinois Episode diamictons at the two stops.

Compared to the diamicton at Stop 1-5, the stream-level diamicton at Stop 1-6 is sandier, less clayey, and its clay fraction contains much more illite than expandable clay minerals. Both diamictons contain much more dolomite than calcite. As we noted at Stop 1-5, the lowest diamicton exposed there correlates to the Kellerville Member of the Glasford Fm., a unit that has been traced as far west as eastern Iowa. The composition of the Stop 1-6 diamicton is consistent with its being the middle Illinois Episode diamicton (Hulick Member of the Glasford Fm.), which extends to about 80 km (50 mi) west of this site.

Table 1-6. Mean values for grain size and clay mineral composition of samples of Illinois Episode diamictons from Stops 1-5 and 1-6. Analytical data for the samples included in these averages are given in Appendix B, Tables B1-5 and B1-6.

Stop no. / unit	Grain size (percent)			Clay Minerals (percent)			n (texture / xrd)	Formation Member
	Sand	Silt	Clay	Exp.	Illite	K + C		
Stop1-6 / IL Episode Dm	40	43	17	11	67	22	7 / 7	Glasford Fm. Hulick M.
Stop 1-5 / IL Episode Dm	15	49	36	40	40	20	5 / 5	Glasford Fm. Kellerville M.

The boulder gravel unit is interpreted as a lag deposit of locally derived clasts, eroded from two sources, diamicton and local bedrock, as a tributary or the AMR incised its channel at this location. The angular nature of many of the boulders, some of which are shale, indicates they were not transported far and probably lie near their source. Evidence suggests that deposits at least 23 m (75 ft) thick and consisting mainly of the Radnor and Hulick Members, were eroded from this site during the late Illinois Episode. These tills were likely the principal source of the boulder lag deposit. This deposit is also the likely source bed of the boulder concentration seen in the modern stream west of this site. Although its age is not precisely known, the boulder bed clearly post-dates the retreat of the middle Illinois Episode glacier that deposited the Hulick Member. The absence of late Illinois Episode diamicton (Radnor Member) indicates the deposit may be post-Radnor in age, and, thus, represents a latest Illinois Episode or Sangamon

Episode event. If correlative with fluvial deposits overlying the Kellerville Member at Stop 1-5, the deposits may represent a high level of the AMR as it cut into the western bedrock upland. The elevation of the base of the gravel at Stop 1-6 indicates that the river/stream incised to 158 m (520 ft) at this location after retreat of the late Illinois Episode (Radnor) ice and incision continued through Sangamon interglacial time. Refer to Figure 1-3A.

The age of the overlying diamicton unit is somewhat problematic. Neither the Sangamon Geosol nor the Wisconsin Episode loesses occur in the section. Considering (1) the absence of those units, (2) the silt inclusions in the diamicton, which resemble Roxana silt, and (3) the texture and clay mineral content of the diamicton, we correlate the mid-section diamicton to the Delavan Member (Tiskilwa Formation). We interpret the included silt to be a remnant of the in situ Roxana, which was entrained into the Wisconsin Episode glacier. All traces of the Sangamon Geosol and Morton loess were eroded from this site.

Sand and gravel, overlying the Delavan Member, separates it from the rest of the Tiskilwa Formation. These may have been deposited when Delavan ice briefly retreated from its limit. *Are these gravels ice-marginal fluvial or subglacial? How do we tell the difference?*

At this location, we are within a few miles of the western limit of the Wisconsin glacier in an area where the glacier left a very large moraine complex (Fig. 1). It is likely that during the time required for the glacier to build the massive moraine, its margin may have fluctuated near that limit enough to yield the advance-retreat-readvance succession found in RH.

Figure 1-6B. Boulder gravel exposed at Stop 1-6 in Rattlesnake Hollow.

Stop 1-7: Midwest Material Company Site, Lacon

Late Wisconsin Episode High Terrace Succession

Tim Kemmis, Ed Hajic, Chris Stohr, Andy Stumpf, Skip Nelson, and Joel Dexter

Note: This outcrop is unstable and unsafe. Do not go beyond the Caution flagging.

Introduction

To interpret past environments, assess natural resources, and conduct environmental planning, it is just as important to understand the Quaternary fluvial record as that of past glaciers. But interpretation of Quaternary sand-and-gravel sequences in the Midwest has been rare, completed at only a few select, widely scattered sites. To date, understanding past outwash environments has been hampered by (1) the lack of a system for describing sand and gravel that is linked to flow-regime bedform concepts and (2) the general failure to recognize differences in the scale of unconformities in sand-and-gravel sequences, and (3) accurate survey measurement. For this stop, we will demonstrate relatively straight forward methods that can be used to interpret past outwash environments. The remaining challenge for this particular site, however, is determining the age and depth of various meltwater incision and back-fill events.

Objectives

At this stop we will consider several questions about Wisconsin Episode outwash and the reoccupation of the AMV during formation of the Illinois River valley:

1. What features do we look for in the outwash succession to interpret past stream flow conditions?
2. What comprises the sand-and-gravel succession underlying the terrace?
3. Were the deposits underlying the terrace deposited by a single event or by several?
4. If deposited by several events, can we relate the different units in the sand-and-gravel succession to specific glacial events or episodes?
5. Why did this reach of the Illinois River reoccupy the AMV?
6. How can we accurately describe thick successions such as these from high, unstable exposures?

Setting

The Incised Illinois River Valley After Glacial Retreat

The present Illinois River valley is a young feature, carved into Wisconsin Episode glacial terranes (Fig. 1). The valley has two contrasting reaches within the Lake Michigan Lobe: the Upper Reach extending westward to Hennepin from the confluence

of the Des Plaines and Kankakee Rivers near Channahon, and the upper Middle Reach extending south from Hennepin to the margin of the Lake Michigan Lobe at Peoria.

The Upper Reach of the Illinois River valley is a relatively uniform width trench that is deeply incised through glacial uplands and into the underlying bedrock. Glaciofluvial and fluvial fill is relatively thin on the trench floor, but thicker sequences are preserved beneath a few high terrace remnants. The breached and incised character of the Marseilles Moraine and older moraines indicates that the trench we see today was carved after late Wisconsin Episode glacial retreat toward the Lake Michigan Basin.

At Hennepin, the river turns sharply south and reoccupies the western edge of the AMV all the way to the western terminus of the Lake Michigan Lobe at Peoria. This reach, called the upper Middle Valley of the Illinois River, is incised deeply into the thick Quaternary succession being examined on this field trip, and the bedrock valley floor is substantially lower in comparison to the Upper Illinois valley bedrock floor. Although the Illinois River Valley reoccupied the western edge of the AMV, a substantial portion of the broad Illinois and pre-Illinois Episode AMV to the east was not incised and exhumed by late Wisconsin Episode events.

The upper Middle Valley is dominated by late Wisconsin Episode terraces underlain by thick sequences of sand and gravel. The highest and oldest terrace is unusually broad, generally comprising the widest part of the valley, and is discontinuously mantled with loess and eolian sand. Stop 1-7 is a quarry exposure of the sediment sequence beneath one of the high terrace remnants. The top of the high terrace at this location varies in elevation, partly because the surface is mantled by eolian sand and silt dunes, and partly because the terrace surface slopes gradually toward the Illinois River. Elevations range from around 570 feet above MSL near the upland wall down to 500 feet above MSL toward the river side of the terrace. The elevation at the described section is at 515 feet MSL. This is about 155 feet below the summit of the adjacent upland to the east (elevation 670 feet MSL) and about 65 feet above the present river (elevation of about 450 feet MSL).

Younger late Wisconsin Episode terraces occur discontinuously as narrow remnants inset against the edge of the high terrace segments. The remaining portions of the valley consist of the modern floodplain and low-elevation Hudson Episode terraces into which uncommonly large Hudson Episode alluvial fans have encroached from the tributary valleys as tributary streams downcut and adjusted to the low level incised by the last deglacial discharges in the Illinois River Valley. The present Illinois River lacks sufficient slope and discharge to remove the alluvial fans formed from sediment delivered from the tributary valleys.

Several types of discharge events are likely to have occurred during retreat of the Lake Michigan Lobe into the Lake Michigan basin, including seasonal meltwater flows from successive ice margins during retreat and wasting of glacial ice, lake-filtered discharge from moraine-dammed pro-glacial lakes, and large magnitude flood events related to failure of morainal dams. Large magnitude (catastrophic) floods tend to be the most

potent of these discharge event types, destroying much evidence of preceding events of lesser magnitude. Development of the present Illinois River valley was likely the result of numerous discharge events. These events include:

1. Meltwater drainage from the Fox River, a major Illinois River tributary, as at least five successive moraines (ice-margins) funneled meltwater into the Fox River valley;
2. Breaching of several Wisconsin Episode moraines and the subsequent drainage of their moraine-dammed lakes. Included in these is the lake that formed behind the Marseilles Morainic System and the associated meltwater discharge along the several-hundred mile extent of the Des Plaines and Kankakee rivers (the "Kankakee Torrent"); and
3. Breaching of the moraine dam of the Valparaiso Morainic System that formed Glacial Lake Chicago during glacial retreat into the Lake Michigan Basin.

How Do We Interpret Outwash Sand-and-Gravel Sequences?

Geologists have long been hampered in interpreting past stream-flow conditions and the (relatively) long-term aggradation of Quaternary sand-and-gravel sequences despite having reasonable knowledge of both modern fluvial environments and stream-bedform genesis based on flume studies. This problem has resulted in large part because there has been no systematic way to describe sand-and-gravel deposits in a way that could be related to stream-flow conditions and because different order bounding surfaces in the sand-and-gravel sequences have largely been unrecognized.

A suitable method for describing sand and gravel was developed by Miall (1978) who devised a lithofacies code for braided-stream deposits that combined grain size and sedimentary structure. Kemmis et al. (1988) expanded this code, allowing for more detailed description of gravel size and sorting as well as adding additional sedimentary structures observed in Wisconsin Episode outwash sequences. The significance of these lithofacies codes is that the sedimentary structures can be related to flow-regime bedforms to interpret past stream-flow conditions (Appendix C). Recognition of vertical and lateral changes in sedimentary structure and grain size indicates how stream-flow conditions varied spatially and through time.

Sand-and-gravel sequences are marked by unconformities on all scales. Miall (1985, p. 270-273; Appendix C) and others have noted that there is a hierarchy to these unconformities or bounding surfaces. The smallest, or first-order, contacts constitute boundaries for individual crossbed sets or beds. Second-order contacts form boundaries for crossbed cosets or a related group of beds. Most third-order contacts are erosion surfaces that bound a particular channel fill, grouping together multiple groups of beds and/or crossbed cosets of lower order. A fourth order would include groups of channels, as in a valley fill, and so forth. Descriptions using a lithofacies code that can be related to flow-regime bedforms and recognition of different order bounding surfaces are essential considerations in answering questions about the record of outwash sedimentation underlying Illinois River terraces.

A further complication to gathering information about outwash sequences is accurately measuring bed thickness and elevation in high, unstable exposures such as this one. We used a reflectorless total station survey instrument to solve this problem (Appendix D). At the stop, Chris Stohr will discuss the instrument and how it was used to study this outcrop.

What Comprises the Outwash Succession Underlying the High Terrace?

The exact thickness of sand and gravel underlying the high terrace is uncertain because of limited subsurface information. The exposed sands and gravels appear to represent just over one-half of the total sand-and-gravel thickness. The 19 m (63 ft) of exposed sand and gravel represents about 55 percent of the 35 m (113 ft) of sand and gravel encountered in an on-site boring that penetrated the complete sand-and-gravel succession, ending in very dense gray till.

The exposed sands and gravels provide a complex and interesting record. At first glance they appear to be the same complex, seemingly incomprehensible assemblage of sands and gravels that have stymied geologists' understanding for decades. But a closer, more careful examination of the outcrop, noting the sedimentary structures and the different bounding surfaces, reveals some important information about the sequence.

First, note that even though the sequence is complex, there is surprisingly little lateral variation across the outcrop – similar sedimentary structures are present at about the same elevation across the exposure. As a result, description and characterization of this type of sequence can be made with lithofacies profiles. We described lithofacies profiles from three representative locations: one on the northern end of the outcrop, one near the center, and one near the southern end. The northern location is shown in Fig. 1-7A and is described in Appendix E.

Second, look closely and observe that there are two major unconformities in the sequence. These third-order bounding surfaces are outcrop-wide angular unconformities that truncate groups of underlying beds. The significance of the unconformities is that they indicate major breaks in sedimentation and the beginning of new depositional events. However, they leave no obvious clue as to each event's age.

Third, having noted the unconformities, we recognize that the deposits underlying the high terrace include at least the three groups of exposed sediments. We have informally designated these as units x, y, and z from the base of the exposure upwards. We can now examine the structures within each group of sediments and gain an understanding of stream-flow conditions for each of these exposed groups.

The lowest exposed unit: Unit x

The lowest group of sediments, Unit x, is not completely exposed, so our understanding is only of the last phase of sedimentation for this group. At the time of the descriptions, 3.6 to 4.2 m (12 to 14 feet) of Unit x were present above the floor of the excavation, but only the upper 1.2 to 2.4 m (4 to 8 feet) were not covered with slump.

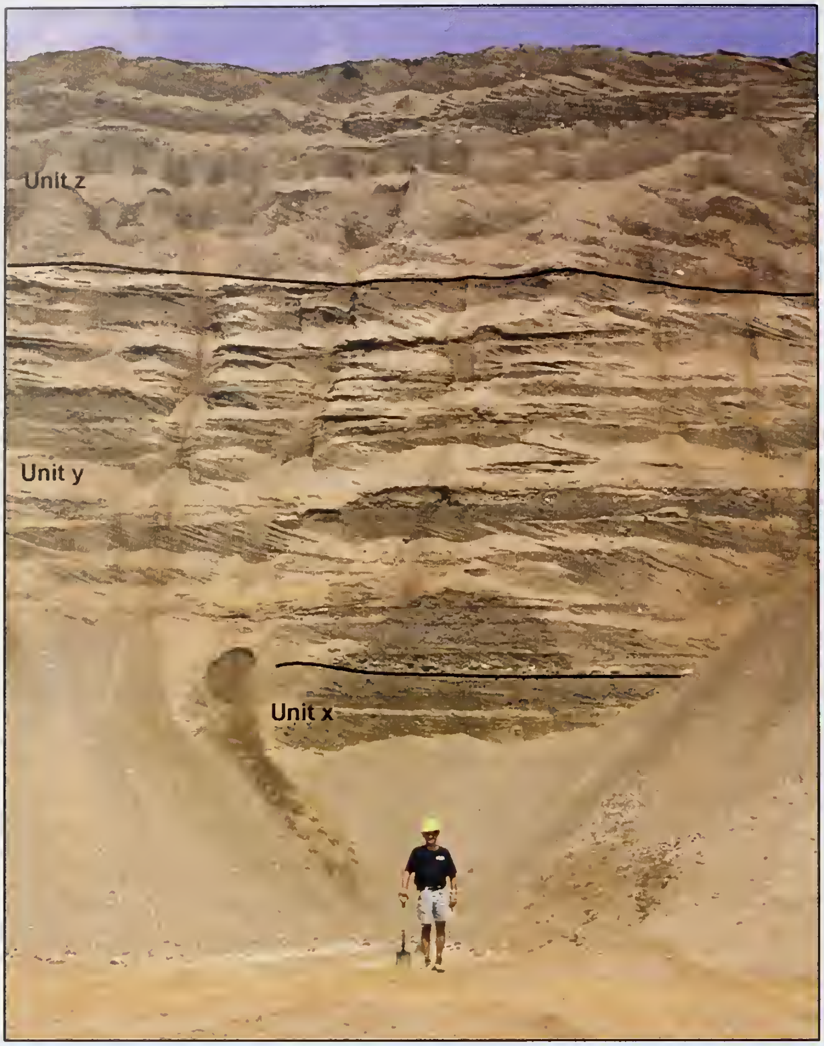


Figure 1-7A. Overview of the described section at the north end of the outcrop. The shovel in geologist Andy Stumpf's hand is 1 m high (3.3 ft).

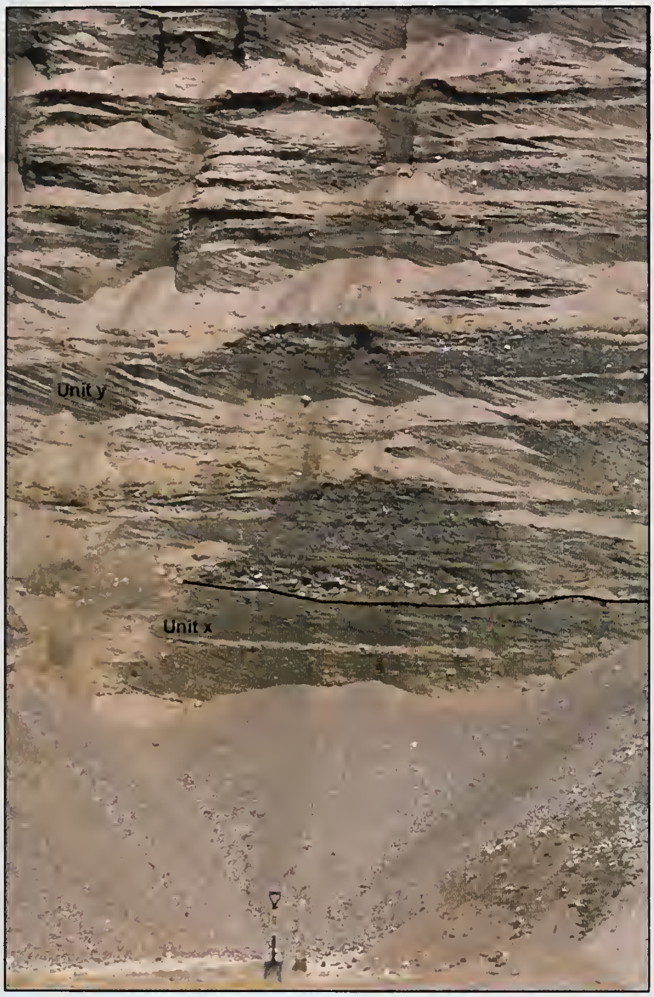
The exposed sequence consists of a succession of trough cross-bedded pebble gravels and sands, facies PGms(t) and S(t), with an upward trend to more finer grained trough cross-bedded sands at the top of the unit (Fig. 1-7A; Appendix E). Trough cross beds are formed by migrating dunes in the higher energy conditions of the lower flow regime (Appendix C). The sequence comprising this unit indicates valley-train outwash deposition of migrating pebbly sand and sand dunes in a large channel, with slightly lower energy, finer grained sediment (sand) deposited toward the top of the preserved sequence.

Unit y

An angular unconformity with almost 2 m (nearly 6 feet) of relief separates Unit x sediments from those of the overlying Unit y (Fig. 1-7B). The unconformity indicates a distinct change in stream conditions and the initiation of a new sequence of sedimentation. At this location, the Unit y sediments are almost 8.5 m (28 feet) thick.

High energy conditions are indicated by the unconformity at the base of Unit y that indicates scour closely followed by deposition of planar-bedded, clast-supported cobble gravels, facies CGcs(pl). Planar-bed conditions occur at the transition between the lower and upper flow regimes (Appendix C) at higher energy stream-flow conditions than migrating dunes (trough cross beds).

The rest of the Unit y succession is similar to that of the underlying Unit x, consisting primarily of an upward sequence of trough cross-bedded pebbly gravel, sandy pebbly gravel, and sand, facies PGms(t), PGms(t)-S(t), and S(t) (Fig. 1-7B; Appendix E), indicating aggradation as dunes of sandy pebble gravel and sand migrated across a large channel floor. Thin diamicton beds are locally present, and in this case, are interpreted to have been deposited from successive events; the thin fine-grained sediment is interpreted to have been deposited under low-energy conditions as stream discharge waned in individual channels followed by deposition of gravel on and in the finer grained sediment as discharge subsequently increased and the overlying sediments were deposited.



As in underlying Unit x, the Unit y sequence also tends to have more finer grained sandy cross beds near the top of the succession, indicating somewhat lower energy conditions and consequent transport of finer grained sediment with time.

The uppermost exposed unit: Unit z

Another angular unconformity, with nearly 2 m (6 ft) of relief across the outcrop, separates Unit z, which is about 6.4 m (21 feet) thick, from the underlying Unit y. Above this unconformity is the coarsest sand-and-gravel unit with the largest sedimentary structures in the exposure, indicating the highest energy stream-flow conditions of all the exposed units. Unit z consists of large, very thick and very deep channel fills (Fig. 1-7C) composed of planar-bedded, matrix-supported cobble and pebble gravels, facies CGms(ccf)-PGms(ccf) in which the u-shaped planar beds mimic the channel form.

Figure 1-7B. Close up of the unconformity between Unit x and overlying Unit y, showing planar-bedded cobble gravels and the overlying succession of trough cross beds. Shovel in foreground is 1 m high (3.3 ft).

These thick channel fills, typically 3.5 to 4.2 m (12 to 14 feet) thick, are overlain by 2 to 3 sets of trough cross-bedded pebble gravels, facies PGms(t) to the top of the exposure.

The Unit z sequence indicates high-energy conditions, with scour of the underlying Unit y sequence and deposition of planar-bedded cobble and pebble gravels in large, deep channels, probably resulting from major flood conditions. With time, stream and sediment discharge dropped, and trough cross-bedded pebble gravels were deposited from dunes migrating over the channels. High-energy flood deposits occur at the top of outwash sequences beneath other terraces in the upper Middle Illinois Valley as well, including those upvalley associated with the high and intermediate terraces at Hennepin (Figs. 1-7D and 1-7E).

As the flood waned here at Lacon, the Illinois River downcut west of what is now the high terrace, leaving the top of the succession well over 20 m (65 feet) above the modern river level. Eolian deposits, including loess (Peoria Silt) and eolian sand (Parkland facies of either the Peoria Silt or Henry Formation) were deposited on the terrace surface.

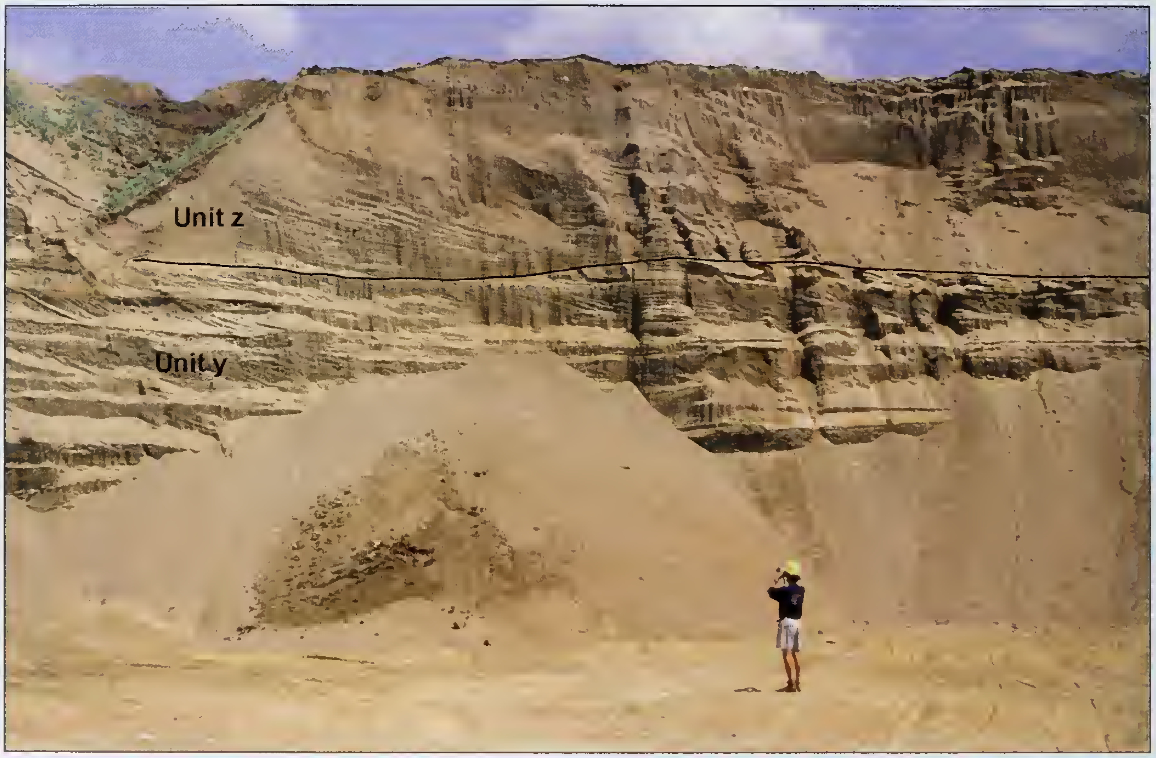


Figure1-7C. Large, coarse-grained channel fills comprise the lower part of Unit z.

Discussion

What can we interpret from the terrace outwash succession?

1. For the outwash succession underlying the terrace surface, distinct sedimentation events are marked by initial scour and development of an unconformity on the underlying deposits (e.g., Figs 1-7A and 1-7B).
2. The coarsest (highest energy) sediments of each sedimentation event occur at the base of the units just above the unconformity.
3. During each sedimentation event, generally lower energy deposition took place with time, the finest grained beds tending to occur at or near the top of the preserved sequence.
4. The coarsest, highest energy unit underlying the terrace is the uppermost unit.

What can we not interpret from the terrace outwash succession to date?

Detailed examination of the outwash succession here and at other places in the upper Middle Illinois River Valley provide some insight into the complexity of the outwash sequence, but several questions remain unanswered:

1. What is the timing and depth of outwash incision-and-backfilling events? There are at least two alternative interpretations for the Lacon sequence. The first is that late Wisconsin Episode flood waters deeply carved the present Illinois River Valley below any existing AMR sand-and-gravel units and backfilled to what is now the high terrace level during several successive Wisconsin Episode events (at least those related to the exposed units x, y, and z). The alternative interpretation is that Wisconsin Episode meltwaters carved the present Illinois River Valley only down into the top of AMR sands and gravels, then backfilled only the upper increment (Unit z) of coarse gravels and sands. For this interpretation, only a single large magnitude flood event would be required to incise the valley and form the high terrace. The units underlying Unit z would be exhumed proglacial Wisconsin Episode or pre-Wisconsin Episode AMR deposits similar to those we will examine tomorrow at Stop 2-4, the Sandy Creek Section.

Figure 1-7D. The high terrace succession at the head of the Middle Illinois Valley at Hennepin. Just as at Lacon, the succession is from multiple depositional events (separated by unconformities) and the uppermost part of the succession has the coarsest, highest energy deposits.

Fig. 1-7E. The intermediate terrace succession of the Middle Illinois Valley at Hennepin. Again, the record consists of a sand-and-gravel succession from multiple depositional events with the coarsest, highest energy deposits at the top of the terrace succession. Both the high and intermediate terrace deposits are upvalley and coarser than at Lacon, and the intermediate terrace deposits at Hennepin are noticeably coarser than the high terrace deposits. The conclusions are evident: Illinois Valley terraces were each deposited by multiple depositional events and the highest energy events of each terrace level are associated with the unit at the top of the sequence.

More research is needed to determine which of these alternatives might be correct. Such research could include (1) physical correlation to determine if the AMR sands and gravels underlying the uplands east of the high terrace area occur at elevations similar to those at this outcrop, making the exhumation of AMR sands plausible, (2) mineralogical studies to determine if mineralogy can be used to correlate sand-and-gravel units, and (3) absolute dating using techniques to provide direct age correlation of the units.

Seismic reflection profiling may be helpful in determining if the structures in the AMR sands and gravels underlying the upland are the same as those in the sands and gravels at depth beneath the terrace. An abrupt change in structure of the sands and gravels at the terrace/upland boundary would suggest that the AMR sands and gravels underlying the uplands do not correlate to sands and gravels underlying the terrace at the same elevation.

A shear-wave seismic reflection traverse 650 m (2,130 ft) long was completed across the eastern part of the high terrace, ending on the adjacent upland about 20 m (65 ft) higher in elevation (Fig. 1-7F). Although both shear-wave and P-wave

seismic reflection gave good results, the low water table rendered processing and interpretation of the P-wave section difficult.

The time-to-depth conversion was possible using available regional borehole data. The present upland on the eastern (right) side of the section is underlain by 35 m (115 ft) of Wisconsin Episode diamictons overlying a 15 m (50 ft) thick sand layer that in turn overlies bedrock. An erosion surface is interpreted to extend downward from the terrace/upland boundary and truncate the entire upland till and sand stratigraphy and up to 10 m (over 30 ft) deeper into bedrock than beneath the upland. Sand-and-gravel sediments on the western (left) side of the transect on-lap the erosion surface and underlie the terrace. Diffractions also indicate the presence of boulders or till rafts in the sand-and-gravel sequence, possibly resulting from erosion of the upland till units.

The interpretation of the shear-wave seismic reflection traverse suggests that the erosion surface underlying the high terrace was produced by major floods in the Illinois River valley during the Wisconsin glacial episode, and that the overlying sands and gravels are late Wisconsin in age. But other methods of correlation, either by mineralogy or absolute dating, need to be completed to confirm that this interpretation is correct. Furthermore, there is other evidence that provides conflicting interpretation and compels additional study and evaluation.

Besides the seismic results, examination of well records for the uplands east of the high terrace indicates that extremely thick AMR sands and gravels do indeed underlie Wisconsin and Illinois Episode glacial deposits at elevations within the range of the exposed sand-and-gravel units at this stop, occurring at elevations between 560 and 460 feet MSL. So it is plausible that Wisconsin Episode floodwaters could have incised down only to, or into, older AMR sands-and-gravels and then deposited just Unit z. Although this interpretation is plausible, it still does not prove that underlying Units x and y correlate to the AMR sands and gravels underlying the uplands. Such correlation would depend on either definitive mineralogical correlation or absolute age dating.

Furthermore, a suite of geomorphic evidence taken collectively as diagnostic of catastrophic flooding (Kehew and Lord 1987) has been documented down the length of the Illinois Valley and attributed to the Kankakee Torrent (Hajic 1990) and could account for deposition of Unit z and valley incision resulting in the high terrace remnants of the upper Middle Illinois valley..

In the Upper Illinois valley, geomorphic evidence includes the Illinois River Valley itself that would have been carved as an inner flood channel. Streamlined bedrock erosional residuals rise above the valley floor. The Illinois valley heads behind the Marseilles Moraine in the Morris Basin where it represents an incised lake basin outlet. Scoured and channeled upland surfaces between moraines on either side of the Illinois Valley represent the outer erosional zone formed during the earliest stages of flood flow.

In the upper Middle Illinois valley, most high terrace remnants that accord with the high terrace at Lacon are interpreted as alcove bars and are preserved on alternating sides of the valley. Most exhibit a lemniscate form with a marginal channel at the foot of the uplands, although that is not the case at Lacon. The aforementioned high terrace at the bend near Hennipin represents a pendant bar that formed in the relatively sheltered lee of the uplands on the south side of the valley. The towns of Pekin and South Pekin are situated atop two streamlined high terraces that represent expansion bars immediately downstream of Peoria and the passage of the Illinois River through the Bloomington Moraine at the head of the lower Middle Illinois valley. The bars were deposited upon a broad, biconcave, scoured surface cut into the Bloomington outwash fan; bar tops accord with the high terrace upstream. In the upper Middle Illinois valley, the catastrophic flood inner channel is represented by the valley area that lies below the high terraces. In this reach the inner channel exhibits a meandering form.

Exactly when the Marseilles Moraine was breached and spillover of Kankakee Torrent floodwaters coursed through other sluiceways and outlets is uncertain. Willman and Frye (1970) estimated the flood occurred between 14.0 and 15.0 ka BP. Hajic (1990) estimated the flood occurred between about 15.5 and 16.0 ka BP. Incision of the inner flood channel definitely predates 15.0 ka BP, an age obtained from organic debris recovered from laminated silts within the flood channel.

In either case, additional research is necessary to definitely correlate units and determine the age of incision and backfilling events in the Illinois River valley.

2. Why did the Middle Illinois River Valley reoccupy the AMV? For this, we do not have the record. The valley features we see today are young, dating to truncation of glacial uplands all the way down valley from the Marseilles Morainic System high in the Upper Illinois Valley reach; i.e., the record of initial valley development has been eroded away by later flood events. Reoccupation of the western edge of the AMV by the Illinois River may have been initiated either from subglacial drainage using the AMV or stream reoccupation along the western edge of the former AMR valley along sags or lowlands on the surface of the Wisconsin Episode glacial sequence as glaciers retreated from the area.

Summary

Deciphering outwash deposition is just like deciphering the record of any other sedimentary deposit. But, to date, understanding outwash successions has been hampered by (1) the lack of systematic description of the deposits in a way that can be related to stream-flow conditions and (2) the lack of recognition of different order bounding surfaces in the successions. This stop illustrates how lithofacies codes related to flow-regime bedforms and recognition of different order bounding surfaces in the outwash succession can provide understanding about the conditions that existed during outwash deposition. Knowledge of the broader geomorphic, stratigraphic and

event contexts allows the formulation of testable hypotheses to better interpret outwash successions.

The key questions that arise from this location, however, are that once we decipher depositional conditions, how do we correlate sand-and-gravel units and date stream incision and back filling? The following questions remain:

1. How deeply did Wisconsin Episode meltwaters incise the Middle Illinois Valley? Can the bedrock floor of the Upper Illinois valley serve as a guide?
2. How many periods of Wisconsin Episode outwash sedimentation were there and how many are discernible. Only one, the flood event that deposited Unit z at this stop? Or were there more, causing deep incision and subsequent deposition of Units x, y, and any underlying units not exposed?
3. If there were several closely related periods of late Wisconsin Episode outwash deposition in the upper Middle Illinois Valley, what glacial events up-valley were they related to?
4. Do the different sand-and-gravel units differ mineralogically, and can that aid in correlation? Does the mineralogy of the units differ enough to affect resource use such as differences in groundwater quality and construction aggregate quality?

These are questions to which future research on the sand-and-gravel sequences in the Illinois River Valley will be directed.

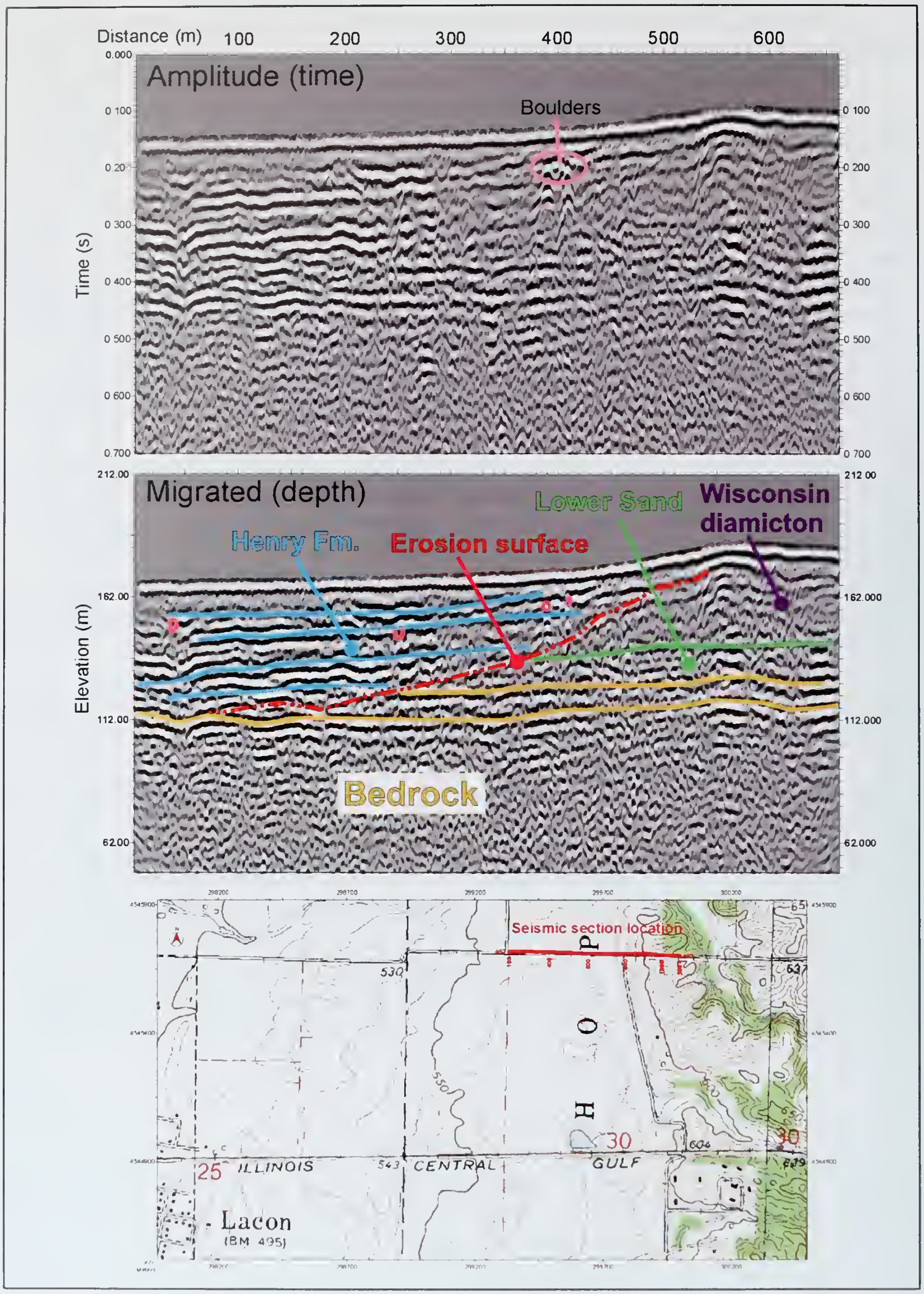


Figure 1-7F: Shear-wave seismic transverse across the edge of the Illinois River high terrace and adjacent upland to the east, and interpreted stratigraphy.

DAY 2

Stops 2-1, 2-2 & 2-3: Route 18 Sections

Wisconsin and Illinois Episode Successions in Uplands East of the Illinois River over the Center of the Ancient Mississippi Bedrock Valley

Don McKay and Dick Berg

Introduction

Several important and interesting outcrops of Quaternary deposits occur along the south side of Illinois Route 18 east of Henry, Illinois. There the highway descends from the uplands, parallel to a westward-flowing, unnamed tributary to the Illinois River for a distance of about 3 kilometers. Erosion of the south bank of the stream has exposed glacial and fluvial deposits between 1.6 and 2.4 km (1 to 1.5 mi) upstream (east) of the confluence of the tributary with the Illinois River. These exposures are above the center of the bedrock valley. The eastern margin of the bedrock valley is 6 km (3.7 mi) to the east of our first stop (Stop 2-1).

Deposits in this area record events that occurred as the AMR was overridden by Illinois Episode and by Wisconsin Episode glaciers from the east. We will begin high in the stratigraphic section in the headwaters of the tributary and work westward toward the Illinois River and down stratigraphic section (Fig. 2-1A).

At Stop 2-1, we will also examine data and discuss results from a 78-m (256 ft) ISGS core (I-1081 Nauman No. 1), collected in 2003 from a site about 400 m (1300 ft) northeast of Stop 2-1. The core penetrated bedrock in the bottom of the AMV at an elevation of 115.5 m (379 ft), which is about 54 m (177 ft) lower than the base of the outcrop exposure at Stop 2-1 and only a few meters above the lowest part of the bedrock valley floor.

Despite being located above the AMV, Stops 2-1 and 2-2 expose a succession of deposits and paleosols typical of the upland landscape east of the AMV, i.e. Wisconsin till over Wisconsin loess over Sangamon paleosol developed in late Illinois Episode till. These sections show that by the middle to late Illinois Episode, this part of the AMV had been filled and capped with sediment, and that the AMR had been displaced elsewhere in the bedrock valley (probably west of this site). Westward of Stop 2-2, at Stop 2-3, the upper part of the Illinois Episode fluvial valley-fill sand and gravel is exposed. There, they intertongue with middle and late Illinois Episode diamictons. The exposed relations suggest that the Stop 2-3 site was an ice-contact setting near the eastern wall of the AMV in middle Illinois time when a glacier overrode the river. Stop 2-4, the last stop of the trip, exposes the thickest outcrop of Illinois Episode fluvial sediment in the MIV and together with a core taken at its base contains a record of deposition in the channel belt of the AMV from pre-Illinois episode time through the late Illinois Episode.

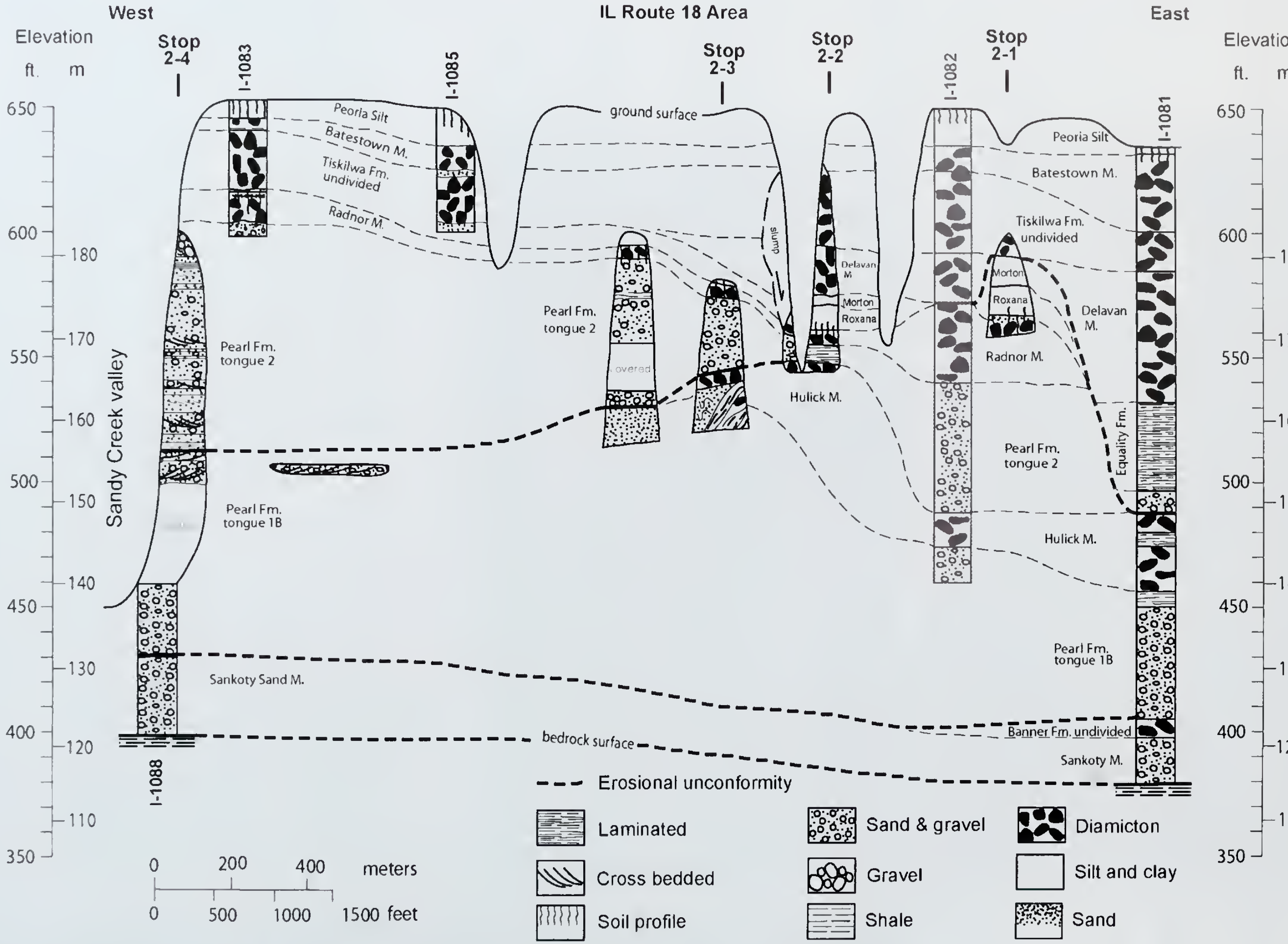


Figure 2-1A. Cross section along Illinois Route 18 provides an overview of lithofacies and lithostratigraphic correlations between field trip Stops 2-1, 2-2, 2-3, and 2-4 east of the Illinois River in Putnam and Marshall Counties. Core I-1082 is 0.4 km (.25 mi) north of the line of cross section.

Objectives

The objectives of visiting the Route 18 sections are to:
1) examine Wisconsin and Illinois Episode glacial and fluvial deposits at a location in the middle of the AMV,
2) study a well-expressed profile of the Sangamon Geosol and discuss evidence for its landscape position and history,
3) examine a relatively complete succession of Wisconsin Episode loesses buried by Wisconsin Episode tills,
4) consider the origin of collapsed diamictons and fluvial sediments forming part of the middle to late Illinois Episode fill in the AMV,
5) study a unique exposure of thick Illinois Episode AMR sand-and-gravel deposits, and
6) examine core samples of the oldest deposit in the AMV (Sankoty Sand Member of the Banner Formation).

Stop 2-1: Sister's Section and Core I-1081

Setting

Stop 2-1 (Figs. 2-1B and 2-1C) lies near the headwaters of the Rt. 18 tributary valley. The base of the section is approximately 30 m (100 ft) below the surface of the Wisconsin till plain and 54 m (177 ft) above bedrock. Core I-1081 (Nauman No. 1) was taken about 400 m (1300 ft) northeast of the outcrop.

General Description

At the base of the section is 0.6 m (2 ft) of weathered, silt loam-textured, weakly stratified diamicton containing common coal and shale clasts. It is correlated to late Illinois Episode diamicton (Radnor

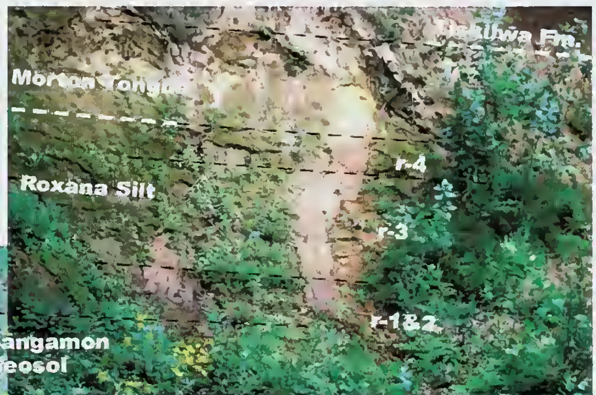


Figure 2-1B. Wisconsin and Illinois Episode deposits and the Sangamon Geosol at Stop 2-1. Lithostratigraphic units, loess zones, paleosol horizons, and contacts are shown.

Member of the Glasford Formation). Two oxidized samples of the diamicton average 27 percent sand, 45 percent silt, and 28 percent clay and have a mean clay mineral composition of 10 percent expandables, 66 percent illite, and 24 percent kaolinite plus chlorite. Analytical data for samples from this outcrop and Core I-1081 are given in Appendix B, Tables B2-1a and B2-1b.

A well-expressed paleosol profile (Sangamon Geosol) occurs in the lower part of the section. Its dark A-horizon overlies a well-expressed E-horizon, and a thick, well-expressed clay-rich B. Weathering extends into stratified sand, gravel, and diamicton, that overlie the Radnor Member. The paleosol at this site has a silty, overthickened, upper solum typical of Sangamon Geosols in the area.

Reddish brown to dark brown silt, 3.7 m (12 ft) thick in the middle of the section, is the Roxana Silt (Wisconsin Episode loess), which conformably overlies the Sangamon Geosol on a gradual contact. The lower part of the loess is leached. The middle 2 m (6.5 ft) contains up to 13 percent dolomite and less than 2 percent calcite, and the upper 0.6 m (2 ft) is leached, contains dispersed charcoal and is a very weakly expressed Farmdale Geosol. Distinctive color zones, which are characteristic of the Roxana Silt and traceable as far south as Arkansas, are present. This suggests that the unit is completely preserved.

Above the Roxana loess is 2.67 m (8.25 ft) of light gray to yellowish brown, dolomitic silt, interpreted to be loess of the Morton Tongue (Peoria Silt). It contains up to 20 to 33 percent dolomite and less than 1 percent calcite. At the top of the section is 4.3 m (14 ft) of reddish brown, pebbly loam-textured, calcareous diamicton (undivided Tiskilwa Formation).

Discussion

The thin weathered diamicton at the base of the exposure is correlated to the late Illinois Episode Radnor Member. At this site, the diamicton is somewhat sandier and less clayey than at Stop 2-2.

As we saw in Rattlesnake Hollow, Sangamon Geosol profiles in the area exhibit a wide range of drainage classes and are developed in a variety of glacial and non-glacial sediments. The paleosol in the lower part of the Stop 2-1 exposure exhibits distinctive horizonation and is developed in fluvial/alluvial and/or slopewash sediments overlying late Illinois Episode diamicton (Radnor Member).

Evidence from Core I-1081 indicates relief on the Sangamon surface of at least 18 m (60 ft) locally. *What is the origin of the stratified sediment overlying the late Illinois Episode diamicton? Is there evidence of erosion and transport of sediment on the Sangamon landscape? Are the deposits glacial, postglacial, or can we determine their age? Did the stratified sediments precede or, perhaps, partly coincide with soil development?*

Higher in the section, the dark, silt loam A horizon of the Sangamon contrasts sharply in color and texture with the underlying light-colored, loamy E horizon. The A horizon includes a significant amount of silt, which is interpreted as an early Wisconsin Episode loessal increment that was partially incorporated into the soil profile. Studies elsewhere have shown that the silt fraction of that zone contains weathered as well as unweathered mineral grains, unlike the underlying E and B horizons, which are uniformly highly weathered (Frye et al. 1974). Therefore, these silty A horizons have been interpreted to include an increment of unweathered sediment, i.e. early Wisconsin Episode loess.

The Wisconsin Episode loess succession (Roxana Silt and Morton Tongue) at Stop 2-1 is similar to, but thicker and more completely preserved than, that displayed in Rattlesnake Hollow (Stops 1-3 through 1-6). The greater thickness of the Roxana Silt at Stop 2-1 may indicate it was nearer its AMV source area than the Rattlesnake Hollow sites or simply that it was downwind of the loess source.

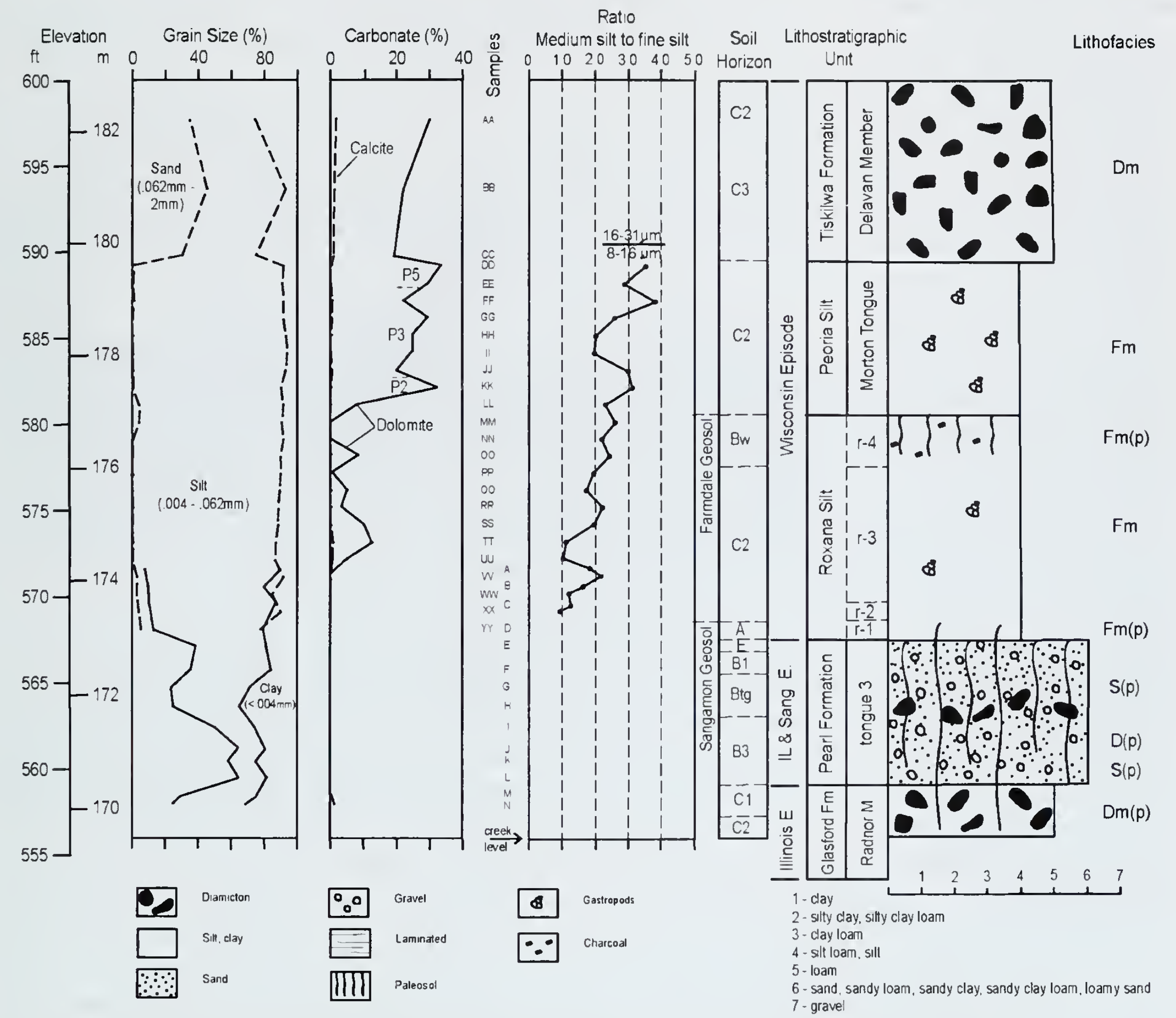


Figure 2-1C. Lithostratigraphy and lithofacies interpretations, grain size, carbonate mineralogy for deposits exposed at Stop 2-1. P2, P3, and P5 are dolomite mineral zones in the Morton Tongue. Zones r-1, r-2, r-3, and r-4 are color zones in the Roxana Silt.

Age determinations on the Roxana Silt and equivalent sediments elsewhere indicate the bulk of the unit was deposited between about 55,000 and about 28,000 ^{14}C yr BP (Curry and Follmer 1992, Grimley et al. 1998), although older ages have been suggested for the lowermost increment (Frye et al. 1974). At Stop 2-1, the lowermost increments of the Roxana loess show considerable pedogenic alteration. Given that this site was adjacent to the AMV where thin increments might be preserved, questions remain. *What is the age of the earliest increment of Roxana loess? Were there significant pauses in early Wisconsin loess deposition? When and how long did they last, and, of course, to what (glacial?) activity in the headwaters were these early increments related?*

Color zones in the Roxana Silt have been related to differences in the color and mineralogy of sediment derived from several sediment source areas in the upper AM watershed. Some color is syn- and/or post-depositional pedogenic alteration (Frye and Willman 1960; Follmer et al. 1979; Grimley et al. 1998). Red hues are thought to indicate sediment from sources in the AMR headwaters areas of Minnesota and northern Wisconsin. Mineralogy of the loess suggests that the brownish gray colored zone in the middle of the Roxana was derived from outwash somewhat richer in illite and dolomite than the reddish zone sources. Perhaps this indicates a source from the Green Bay and/or Lake Michigan glacial lobes, which overrode Paleozoic carbonate and shale. Alternatively, this gray sediment may have come in part from an early Des Moines lobe. The upper 1.0 m (3.3 ft) of reddish Roxana Silt is leached of carbonate and contains dispersed charcoal fragments. The reddish color has been suggested as partly due to a northern source and partly due to weathering. The charcoal has not been dated at this section.

The Morton Tongue (lower part of the Peoria Silt) was overridden by the Lake Michigan glacial lobe. Its base along the AMV dates to about 24,500 ^{14}C yr BP, and it was buried in this area by the glacier that deposited the Wisconsin Episode till (Delavan Member) shortly after 20,780 ^{14}C yr BP. The carbonate zones present within the Morton Tongue (Fig. 2-1C) suggest that the deposit at Stop 2-1 is not truncated significantly. Above a transition zone at the base are three zones, P-2, P-3, and P-5, defined elsewhere and widely traced in Mississippi Valley loess (McKay 1977). Zone P-2 is an early high-dolomite zone derived from late Wisconsin outwash carried into the AMV beginning 25,000 to 24,500 ^{14}C yr BP from headwaters near Lake Michigan where Niagaran dolomite crops out and drift and outwash that originated there are rich in dolomite (McKay 1977, Follmer et al. 1979, Grimley et al. 1998). Zones P-3 and P-5 record combined outwash sources in the upper Mississippi and northeastern Illinois, an upward trend toward increasing dolomite indicates the increased predominance of outwash from northeastern Illinois over other sources as the Lake Michigan glacial lobe approached central Illinois. *How do the structure and density of the loesses at stop 2-1 compare to those in loess at stop 1-3 in Rattlesnake Hollow?*

Because the location of the early to middle Wisconsin AMV is uncertain, we used trends in the grain size of loess deposits to help determine the direction of the local loess source. Loess deposits derived from glacial valley trains in the Midwest have well-documented grain-size trends (Smith 1942, Frazee et al. 1970). The deposits become

finer grained with increasing distance from the source valley. Samples of the Morton Tongue were collected from Stop 2-1 and several outcrops in the local area. Grain-size analyses of the loess at Stop 2-1 (Fig. 2-1C) show that later increments of the loess were coarser than earlier increments. *What caused this trend in grain size?*

Several factors might influence the trend. Perhaps the near valley margin was progressively eroded, decreasing the distance between the source valley and the Stop 2-1 site during the 30,000 years or so that loess accumulated. Perhaps aggradation of the fluvial surface raised the elevation of the source and thereby effectively decreased bluff height allowing transport of coarser silt to the site. Perhaps long-term changes in grain size of material transported in the valley occurred as the Wisconsin glacier pushed farther south into the AMR watershed.

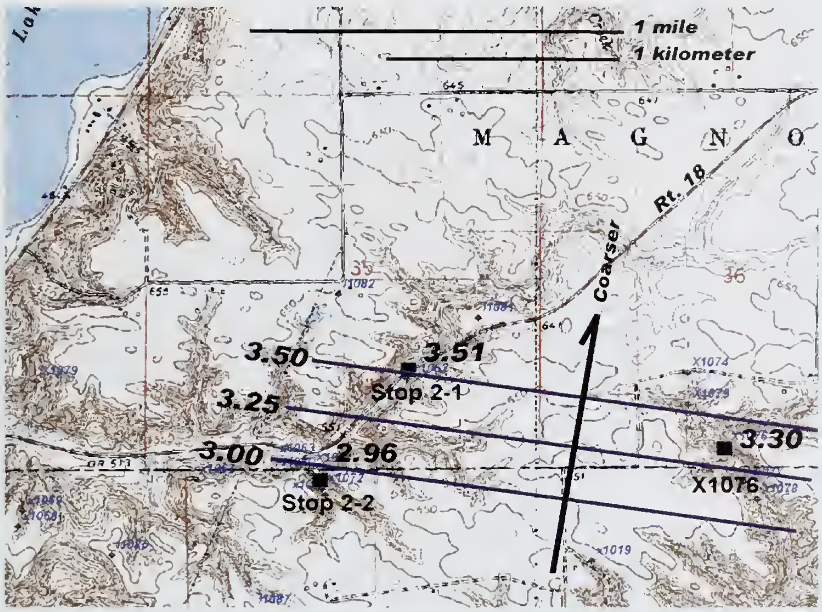


Figure 2-1D. Contoured average values of the ratio of medium silt (.016-.031 mm) to fine silt (.008-.016 mm) for samples of late Wisconsin Episode loess (Morton Tongue) at three sites east of the Illinois River, Henry 7.5-minute Quadrangle.

The direction to the source valley from the three sampling sites is indicated by Fig 2-1D, which shows ratios of silt fractions of loess samples from Stop 2-1 and two other sites. These data indicate loess grain-size has a coarsening trend to the north northeast. This result is consistent with regional observations from drilling that have not found evidence of the early to middle Wisconsin Episode valley to the east of the Route 18 sites, and outcrop evidence from Clear Creek (Stop 1-1) that suggests the main stem was there just prior to being overridden by the Wisconsin Episode glacier. Based on Clear Creek, the valley could have been about 2 to 3 km (1.25 to 2 miles) to the north of Stop 2-1.

ISGS Core I-1081(Figs. 2-1E and 2-1F) contributes further to understanding the local paleogeography and Wisconsin history during the time immediately before the AMV was overridden by the Wisconsin glacier between 20,500 and 20,350 ^{14}C yr BP. Drilled in 2003 at a site about 400 m (1300 ft) northeast of Stop 2-1, the borehole penetrated Wisconsin diamictons over Wisconsin lacustrine sediments over Illinois Episode deposits to bedrock. The lacustrine deposits (Equality Fm.) are of particular importance. They are thick and organic rich and fill a lake of unknown size, which likely occupied a

tributary to the AMV during the Wisconsin Episode. The core shows the tributary was incised into middle Illinois Episode deposits, was drowned and filled with lake sediment, and buried by the late Wisconsin Episode glacier. Missing from the core are the Wisconsin loesses, last interglacial soil, and late Illinois glacial and proglacial sediments (Morton Tongue, Roxana Silt, Sangamon Geosol, Radnor Member, and the upper part of the Pearl Formation). Sediments infilling the tributary include weathered gravel at the base and 9.5 m (31 ft) of organic lacustrine silt. Plant remains from six samples were used to determine the age of the lake. They range in age from 24,260 +/- 760 ^{14}C (29,099 +/- 805 calendar) yr BP near the base to 20,780 +/- 140 ^{14}C (24,892 +/- 374 calendar) yrs BP at the top (Fig. 2-1D).

Evidence elsewhere indicates that deposition of the Peoria loess began along the AMV between 25,000 and 24,500 ^{14}C yr BP and that the AMR was diverted to its modern channel by the Lake Michigan lobe glacier between 20,500 and 20,350 ^{14}C yr BP (Glass et al. 1968, Follmer 1979, McKay 1979, Curry 1998).

These ages and the record in Core I-1081 and at Stop 2-1 allow the following interpretation of events. Some time following deposition of the late Illinois Episode diamicton (Radnor Member), the late Illinois Episode upland was incised, probably by a tributary to the AMV. Incision began as early as the late Illinois Episode and continued into the Wisconsin Episode. Absence of the Roxana Silt in Core I-1081 indicates erosion postdates the early to middle Wisconsin Episode deposit. Lacustrine sediment in Core I-1081 records the creation and infilling of a lake beginning about 24,260 ^{14}C yr

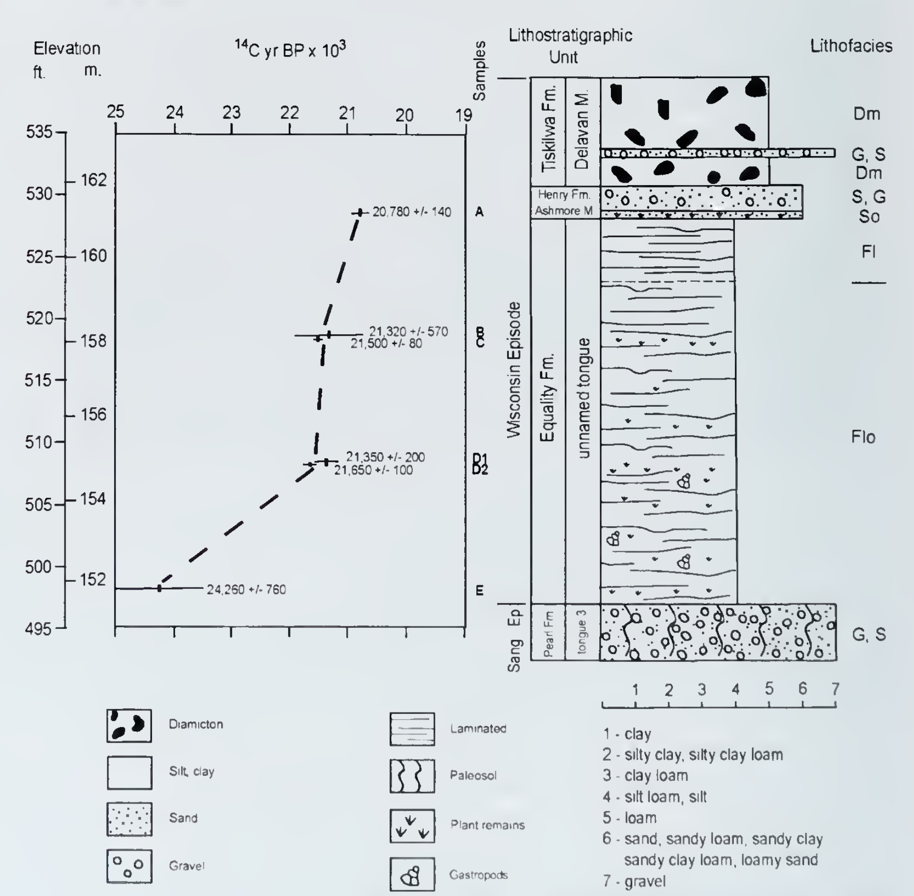


Figure 2-1E. Lithostratigraphy and lithofacies interpretations and radiocarbon ages of deposits sampled in Core I-1081, located 600 m northeast of Stop 2-1.

BP, suggesting that aggradation of the mainstem AMV had blocked the mouth of the local tributary at that time. Loess deposition at Stop 2-1 during this same period indicates that bare surfaces persisted on the AM valley floor and continued to serve as a loess source. Lake infilling continued while the Wisconsin Episode glacier in northeastern Illinois approached central Illinois, and ceased when the glacier overrode the local lake and deposited diamicton (Delavan Member) shortly after 20,780+/-140 ^{14}C yr BP.

The youngest age, 20,780 +/- 140 ^{14}C yr BP on lake sediment from Core I-1081, predates the date suggested for AMR diversion by about three or four hundred years. We believe these results are compatible with the following facts and events related to the diversion of the AMR.

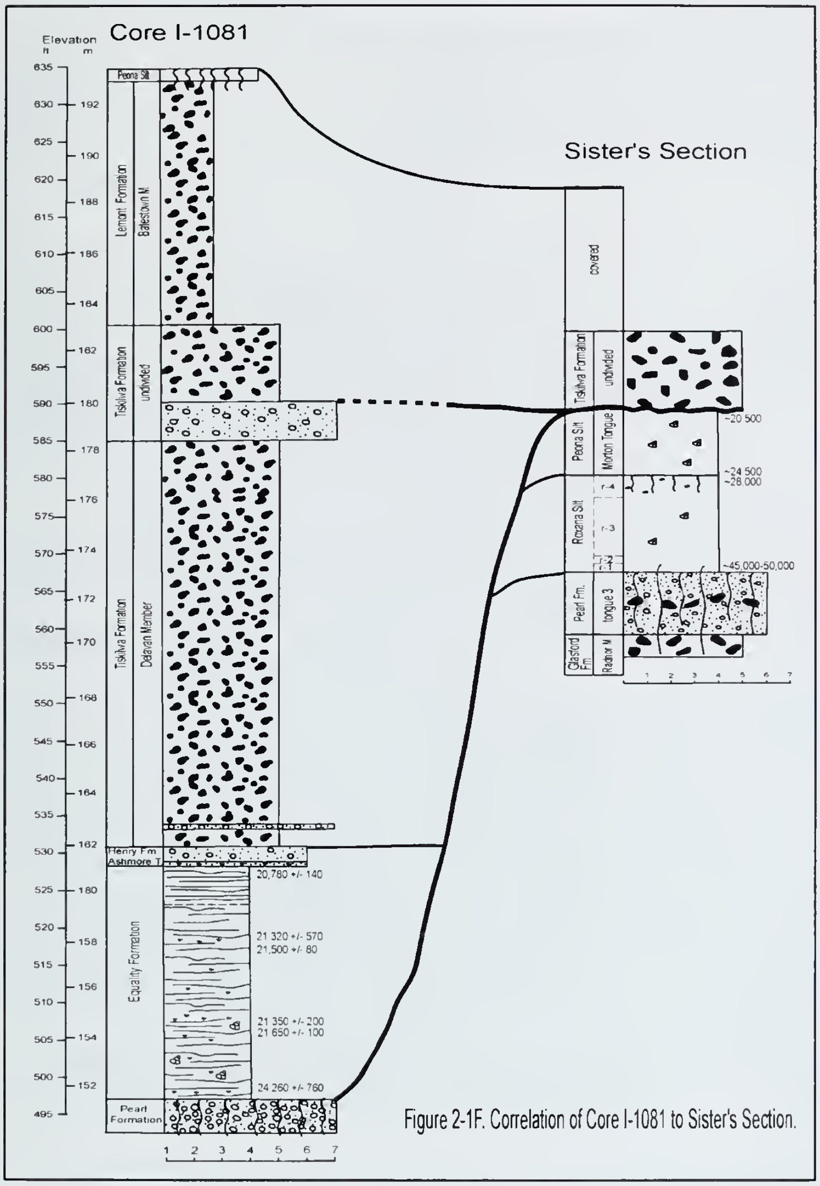


Figure 2-1F. Correlation of Core I-1081 to Sister's Section.

The slackwater lake site at Core site I-1081 is located near the easternmost reach of the mainstem of the AMR valley in central Illinois during the early to middle Wisconsin Episode. It is at least a kilometer and perhaps several kilometers east of the eastern bluff of the river in an area that was at or near the location of first encounter between the advancing Lake Michigan glacier and the AMR. The age of the uppermost lacustrine sediment approximates burial of the slackwater lake by the Lake Michigan glacier. Blockage of the AMR occurred after the Core I-1081 site was overridden. Blockage may have been a gradual, rather than instantaneous, occurrence. The AMR likely maintained its course along the glacier margin for a time, eroding both the ice front and older valley fill, as the river was pushed westward. Eventually constricted between the ice

sheet and the bedrock-defended western upland, the river was blocked, forming Lake Milan to the north. The lake filled and spilled over a divide at Rock Island, and diversion to the modern Mississippi River channel was completed. The record of the diversion, observed and dated (20,350 ^{14}C yr BP) in sediments along the post-diversion river at Lomax in western Illinois (Curry 1998) post-dates our youngest sample (20,780+/-140 ^{14}C yr BP) by several hundred years. The difference between these ages may indicate the imprecise nature of the record and sampling or may be indicative of the time it took to block and divert one of the largest rivers in North America.

Stop 2-2: December Section

Setting

This brief stop is about 500 m (1600 ft) downstream of Stop 2-1 on the south side of the highway. It includes two stream cut exposures. Nearest Highway 18 is a stream bank that exposes the toe of a landslide. Upstream in the lower end of a northward flowing gully is an intact succession of deposits. We will make a short stop at both.

General Description

The first exposure shows 1.5 m (5 ft) of loam-textured, calcareous diamicton at the base overlain by 2.1 m (7 ft) of sand and gravel, which is overlain by 1.5 m. (5 ft) of reddish brown, calcareous, loam-textured diamicton on a contact that shows evidence of shear.

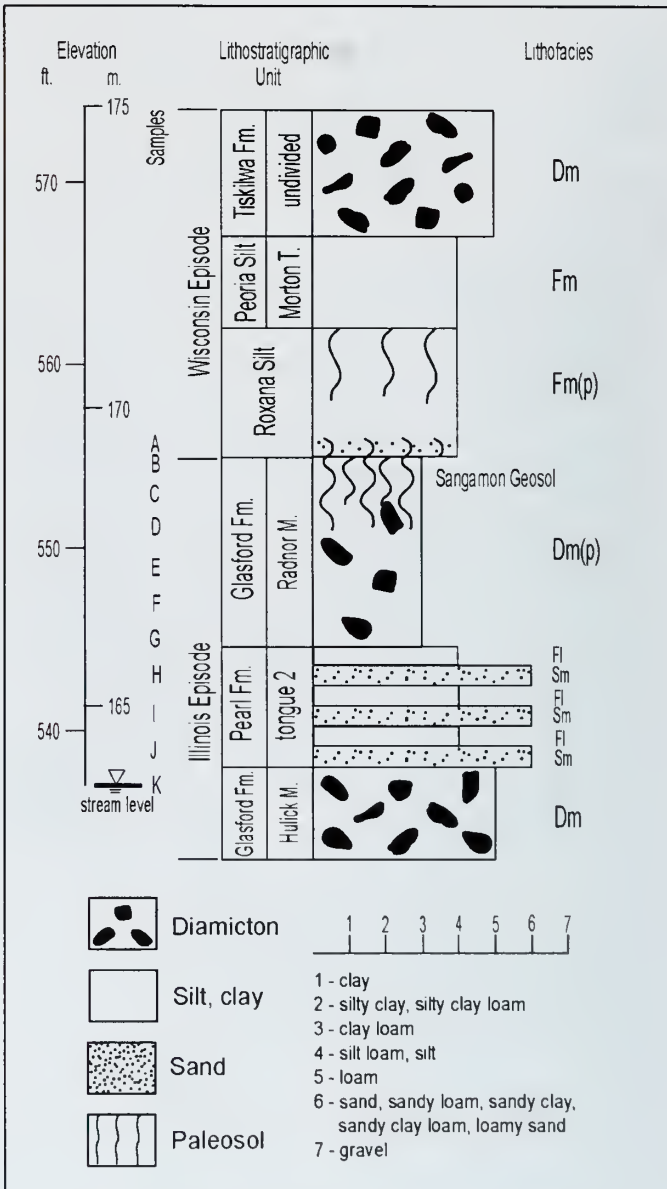


Figure 2-2. Lithostratigraphy and lithofacies interpretations of deposits exposed at Stop 2-2.

The second exposure (Fig. 2-2) occurs a short distance upstream in a gully that enters the main stream from the south. It shows 0.5 m (1.6 ft) of calcareous, coal-rich, loamy and texturally variable diamicton (Hulick Member), overlain by 1.5 m (5 ft) of bedded sandy silt, overlain by 4 m (13 ft) of silty clay diamicton (Radnor Mbr.) with the profile of the Sangamon Geosol in its upper part. Above the Sangamon

Geosol are 2.1 m (7 ft) of Roxana Silt and 1 m (3 ft) of the Morton Tongue, the upper part of which is covered by slump debris.

Discussion

At the first exposure (near the road), a landslide of unknown age (probably historic) has carried Wisconsin Episode diamicton (Tiskilwa Fm.) down slope atop Illinois Episode sand and gravel and diamicton (Pearl Formation over Hulick Member). Missing from the section are units probably totaling more than 7 m (23 ft) thick, including the late Illinois Episode diamicton, last interglacial soil, Wisconsin loesses and the lowermost Wisconsin Episode till.

This landslide site is an example of a common challenge in mapping of surficial deposits in the area. Much of the slope area in the major tributaries of the Illinois River has undergone mass movement. Many and perhaps most of the Quaternary exposures are significantly disturbed by slumping. This requires extra effort early in the mapping project to identify sites from which the stratigraphic framework can be reliably established. Then mapping takes extra time and extra digging because the contacts and materials are severely disturbed.

The second exposure (in the north-flowing tributary) shows the intact succession from the middle Illinois Episode diamicton (Hulick M.) upward through the younger Wisconsin loess (Morton Tongue). This is the only exposure we will see on the trip of relatively unweathered late Illinois Episode diamicton (Radnor Member), which at this site is a silty clay loam to silty clay texture and is significantly more illitic (81 percent illite) than the other Illinois Episode diamictons.

Stop 2-3: Kettle Section

Setting

Like the other Route 18 sites, this site overlies the AMV, but unlike at Stops 2-1 and 2-2, this stop contains thick, coarse-grained fluvial deposits, overlying and interbedded with glacial diamictons (Fig 2-3A, 2-3B, and 2-3C), and the section is cut by faults. The exposure occurs on a high cut bank on the south side of the stream. It slumped recently, exposing a thick section of the upper deposits. The poorly exposed base of the section lies at an elevation of 158 m (520 ft), which is about 43 m (140 ft) above the bedrock surface in the AMV. Less than 100 m (300 ft) downstream of Stop 2-3 is an exposure that we will not visit, but which is important, because it has in the past exposed a succession of deposits like those in the upper part of Stop 2-3 and those at Stop 2-4. That site, the Little Sandy Section, allowed the thick Illinois Episode fluvial succession of Stop 2-4 to be traced to within 100 m of Stop 2-3.

General Description

Beginning at the base in the lower left (east) part of the section, exposed are interbedded sand, sandy silt, gravel, and diamicton, totaling more than 13 m (42 ft) thick. These deposits dip steeply from left to right across the face of the exposure. The lower part of this succession is predominantly sand, silt and silty sand (Fig. 2-3C). Up-section these deposits are mostly loam-textured diamicton. This lower succession is cut by numerous small-offset faults at high-angle to the attitude of the beds. The entire lower part of the section appears to have been rotated about 20-25 degrees from the horizontal. Along the upper part of this face of the exposure, slump debris comprising reddish diamicton derived from up-slope and up-section, cuts into the underlying deposits. These resemble the slump deposits seen at Stop 2-2.

At the top of the rotated deposits is 2 to 3 m (6.6 to 10 ft) of unoxidized to oxidized, loam-textured diamicton that is present across the whole face of the exposure. Samples of the unoxidized diamicton have an average clay mineral composition of 4 percent expandables, 67 percent illite, and 29 percent kaolinite plus chlorite (Appendix B, Table B2-3). Near the west end of the exposure, stratified silty clay and silty sand underlie the diamicton and display strongly contorted bedding. The loam diamicton is overlain by about 5 m (16 ft) of flat lying, matrix-supported, calcareous, pebble gravel containing cobbles up to about 15 cm (6 in). This unit is cut by several high-angle reverse faults with associated drag folds. It is overlain by 1 to 2 m (3 to 6 ft) of red weathered sand and gravel.

Unconformably overlying the red weathered zone are complexly deformed diamictons, silt, paleosol, and sand and gravel. An accurate interpretation of the age of these complex upper deposits and soils is important to understanding the age and history of the underlying deposits. The upper part of the exposure is difficult to reach. Oxidized, calcareous, silty-clay-loam textured diamicton from beneath a paleosol in this upper zone has a clay mineral composition of 7 percent expandables, 82 percent illite, and 11 percent kaolinite plus chlorite.

Discussion

High-angle reverse and normal faults, folds, and steep tilted of beds of the lower part of the section suggest let-down of the sediments over a buried ice block. Although faulted, the dipping bedded sediments are largely intact. *Is this consistent with let-down over melting ice?* Multiple thin diamicton beds interbedded with the sands and gravels suggest multiple local debris flows deposited the diamicton.

Thick gray, loam-textured diamicton in the middle of the section has a texture and clay mineral composition consistent with that of the middle Illinois Episode diamicton (Hulick Member). *How was the thicker diamicton in the middle of the section deposited? Is it also a flow or was it deposited subglacially?*

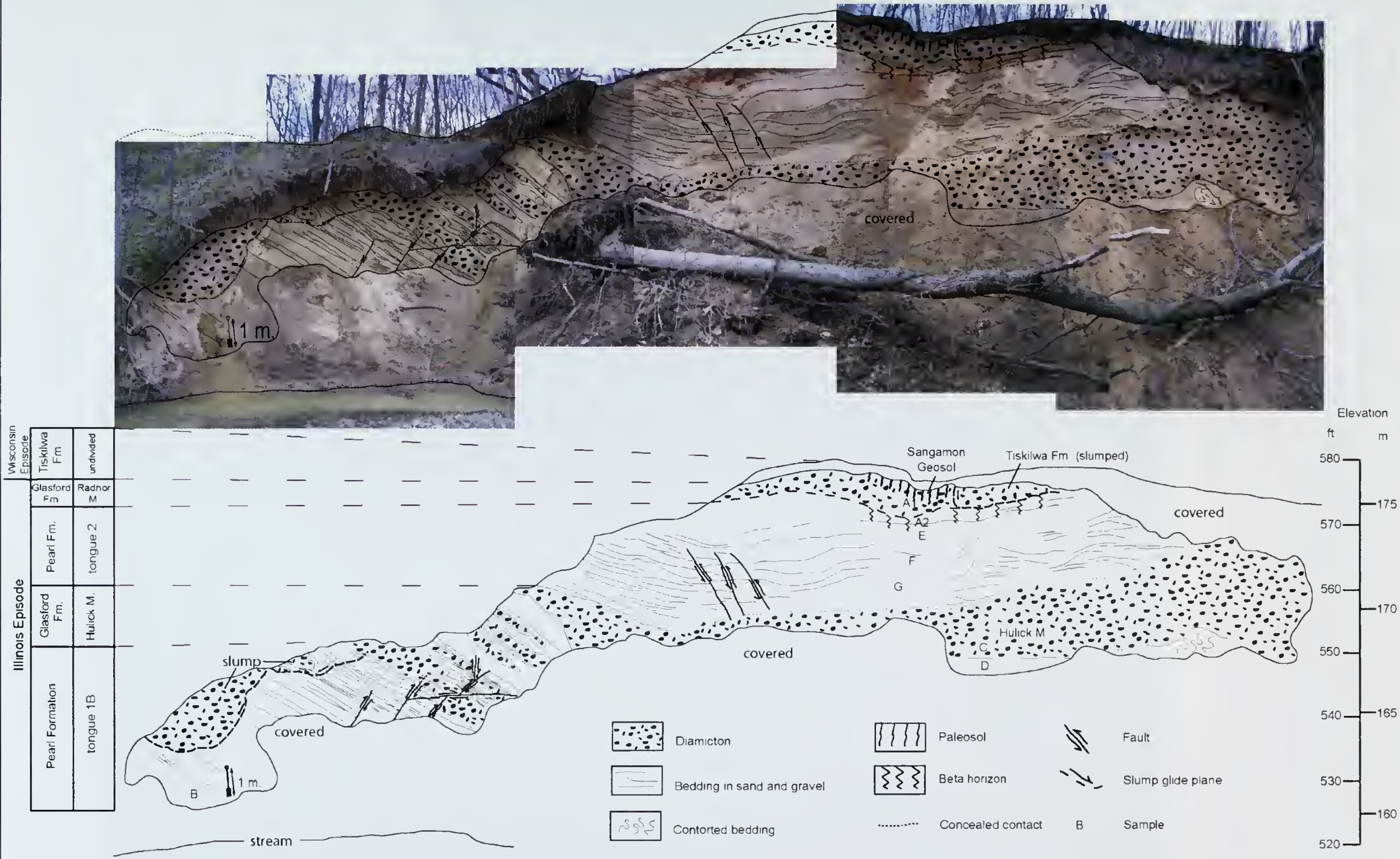


Figure 2-3A. Photomosaic and sketch of Kettle Section (Stop 2-3) showing bedding, contacts, structures, lithofacies, and lithostratigraphic interpretations. Photos and mosaic by E.D. McKay.

Gravel that overlies the middle Illinois episode diamicton (Hulick M.) and underlies the late Illinois Episode diamicton (Radnor M.) is correlated to tongue Pe-2 of the Pearl Formation. This unit is relatively flat lying compared to underlying deposits, but it also shows ice-contact collapse features (Fig. 2-3B). *Could this unit have been deposited by the AMR as it returned to the AMV upon the retreat of the margin of the middle Illinois glacier? Is the deposit consistent with AMR channel-belt sedimentation?* We will want to compare the deposits here to those at the next stop.

The paleosol near the top of the section is interpreted as a Sangamon Geosol developed in silty parent material overlying late Illinois Episode diamicton (Radnor Member). Although incompletely exposed, the paleosol clearly underlies Wisconsin Episode sediments. Its stratigraphic position above a silty clay loam, illitic diamicton is like that of the Sangamon Geosols up valley (east) at Stop 2-2 and down valley (west) at a nearby exposure (X-1067 on Fig 2-1C) 100 m (330 ft) away. At X-1067, the Sangamon Geosol is developed in late Illinois Episode diamicton (Radnor Member), which has a texture and composition like that at Stop 2-2. Radnor till at X-1067 overlies sand and gravel (correlated to tongue Pe-2 Pearl Formation), as it does here at the Kettle Section. The red zone that is clearly visible from the base of the Kettle Section is a beta horizon related to formation of the Sangamon Geosol.

Figure 2-3B. Reverse fault (dashed line) in upper gravel (Pearl Formation tongue 2) exposed in the Kettle Section (Stop 2-3), Marshall Co., IL. Shovel is 1 m (3.3 ft) long

A slump greatly complicates the upper part of the Kettle Section. Its glide plane has brought Tiskilwa diamicton into juxtaposition with Illinois Episode sediments and with silt of the Roxana and Morton loesses, which are thin, sheared, and poorly exposed.

Stratigraphic relations in the Kettle Section, especially in the local

context of the December and X-1067 sections, confirm the assignment of an Illinois Episode age for the upper diamicton, sand and gravel, and lower diamicton. At the X-1067 site down-valley, the middle Illinois Episode till (Hulick M.) is absent, suggesting it was eroded by the river that deposited the upper gravel (tongue Pe-2) at Kettle. This suggests that the succession at Kettle is a succession deposited at the margin of the middle Illinois Episode glacier (represented by Hulick till deposits) as it overrode the AMR (represented by Pearl gravel deposits).

Figure 2-3C. Tilted and micro-faulted sandy silt interbedded with loam-textured diamicton exposed in the Kettle Section (Stop 2-3), Marshall Co., IL. Shovel is 1 m (3.3 ft) long.

Stop 2-4: Sandy Creek Section and cores I-1083 and I-1088

Late Wisconsin Episode Diamictons over Illinois and pre-Illinois Episode Valley Fill in the Ancient Mississippi Valley

Don McKay, Dick Berg, and Tim Kemmis

Note: This exposure is steep. Please be careful and be aware of the potential for falling rocks.

Objectives

The objectives of visiting the Sandy Creek Section (Fig. 2-4A) are to:
1) examine deposits that fill the AMR in the upland east of the Illinois River valley,
2) view more than 40 m (130 ft.) of AMV sand and gravel, the thickest exposure of post-Sankoty, pre-Wisconsin Episode fluvial deposits in the area,
3) discuss Wisconsin and Illinois Episode deposits from a core in the upland above the section,
4) interpret the bedding and lithology of the exposed AMR deposits, and
5) examine samples of red sand (Sankoty Member?) encountered in a core drilled below the section.

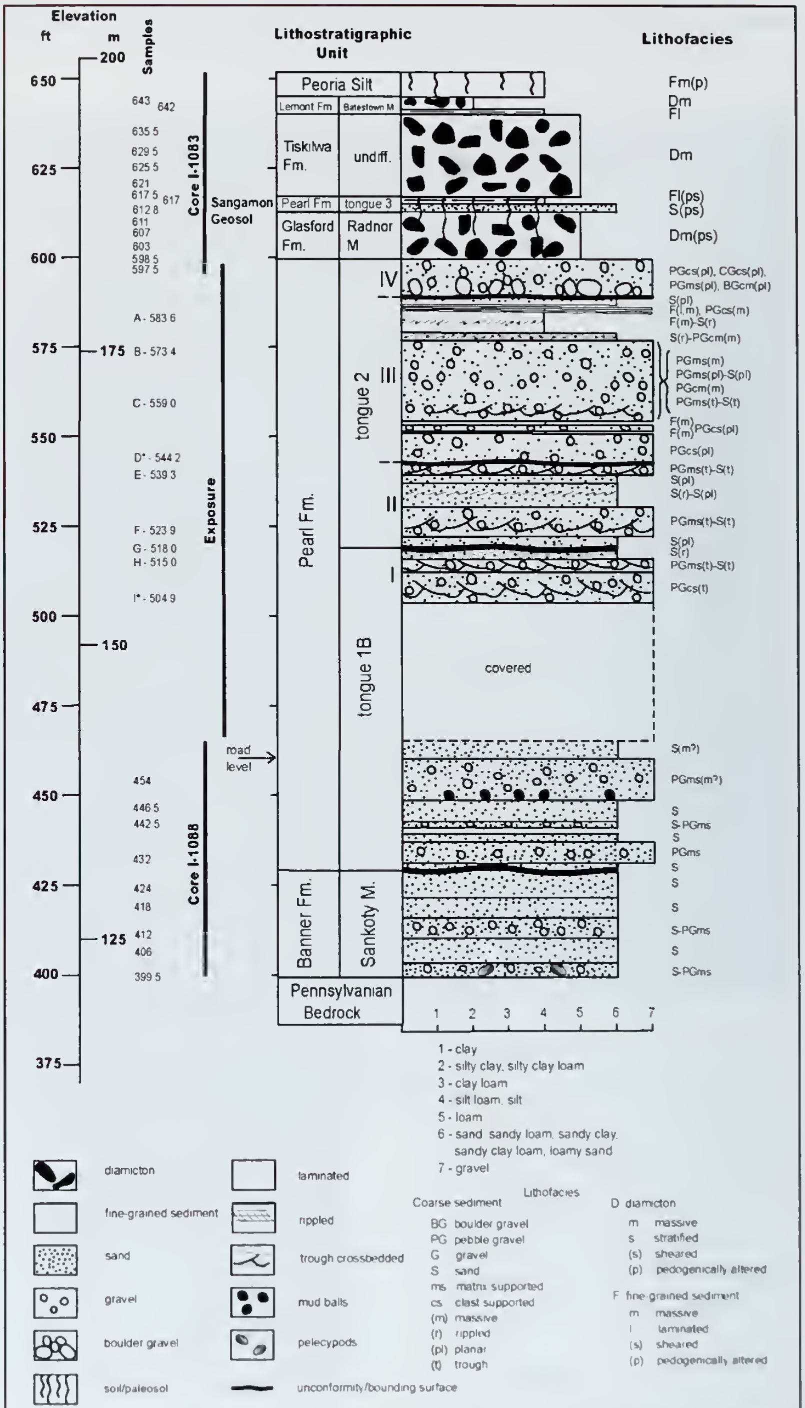


Figure 2-4A Lithostratigraphy and lithofacies interpretation of deposits exposed at Stop 2-4, Sandy Creek Section, and penetrated in Cores I-1083 and I-1088.

Setting

Sandy Creek is one of the largest tributaries of the middle Illinois River. Its 1.2 km (.75 mi)-wide valley is incised 60 m (200 ft) below the adjacent uplands. Its

headwaters, 40 km (25 mi) east of the field trip area, originate in a temporary outlet where glacial Lake Pontiac (late Wisconsin Episode) spilled through the Minonk Moraine (Fig. 1) during Lake Michigan lobe retreat (Willman and Frye 1970). The exposure was described previously by students and faculty from Illinois State University (Nelson et al. 2002). Two cores drilled at the site in 2003 are the basis for our revised stratigraphic interpretation.

General Description

The total thickness of AMR fill at this location, determined from a core drilled in the upland above the outcrop, the outcrop, and a core drilled at the base of the outcrop is about 77 m (251 ft) (Figs. 2-4A and 2-4B). Analytical data for samples from the cores and outcrop are given in Appendix B, Tables B2-4a and B2-4b.

Core I-1083 was taken on the upland immediately upslope of the outcrop at a surface elevation of 199 m (654 ft). It penetrated 11.3 m (37 ft) of silt and diamictons over a truncated paleosol in diamicton, ending in gravel correlated to the gravel about 1 m (3 ft) below the top of the outcrop.

The outcrop exposes a succession of four thick sand-and-gravel units deposited as bedload by the AMR. The combined thickness of the four units is about 27 m (90 ft.). Unconformities separate the units, and the thickest, coarsest beds for each unit, representing the highest energy conditions, occur at or near the base of each unit. A detailed description is given in Appendix F. A brief description follows:

The uppermost exposed unit, **Unit IV** (Fig. 2-4C), is 3.2 m (10.5 ft) thick, and oxidized yellowish brown. This unit is the coarsest sand-and-gravel unit at this location and consists of planar-bedded boulder, cobble, and pebble gravel in the lower half of the unit, and planar-bedded pebble gravel in the upper half.

The underlying **Unit III** (Fig. 2-4C) is more than 14 m (47 ft) thick, and it is also oxidized yellowish brown. Cross-bed dip directions indicate flow to the west-southwest for this unit. Stream flow strength fluctuated during aggadation of this unit. The coarsest deposits occur at the base and include well sorted, planar-bedded, clast-supported pebble gravels, facies PGcs(pl). Shallow troughs or channels cut in the tops of these gravels are filled with massive silts and very fine sands, facies F(m), deposited during periods of waning flow in the course of episodic sedimentation of the pebble gravels. Overlying the gravels is a thick sequence of trough cross-bedded sandy pebble gravel and sand, deposited as dunes migrated over the channel floor. The trough cross-bedded sands and gravels are overlain by massive to planar bedded sands and pebbly sands and ripple-drift, cross-laminated sands. Low energy, massive, laminated, and ripple drift cross-laminated silts and sands occur near the top of the unit.

The underlying **Unit II** is more than 6 m (20 ft) thick and oxidized yellowish brown. Cross-bed dip directions in this unit, like that in the overlying unit, are to the west-southwest. Interbedded trough cross-bedded pebble gravel and sand occur at the base

of the unit, overlain by low energy ripple drift and thinly bedded to laminated sand. Trough cross-bedded sand and pebbly sand occur at the top of the unit.

The lowest 6 m (20 ft) of sands and gravels exposed at the base of the section are designated as **Unit I** (Figs 2-4B and 2-4C). Unit I differs distinctly from the overlying units in being slightly pink, rather than yellowish brown, and flow directions are to the east-southeast, rather than to the west-southwest as in overlying units. At the base of the section is a very thick, only partially exposed bed. Because of the limited exposure, it is uncertain whether the exposed 2.7 m (9 ft) thick foresets of this bed are cross beds, representing migration of a very large dune during extreme flood conditions, or if the foresets are lateral accretion beds of a transverse channel fill. The succession overlying this bed changes upward from trough cross-bedded pebble gravels and sand, in which ISU geologists have noted flute casts (Nelson et al. 2002), to ripple-drift cross-laminated sand to thinly bedded and laminated sand, indicating decreasing flow strength as this unit was deposited.

Figure 2-4B. Sandy Creek Section, Stop 2-4, and described Units I through IV.

Core I-1088 was drilled on the debris apron at the base of the outcrop slope to determine the succession of deposits below the outcrop. It penetrated 19.5 m (64 ft) of sand and gravel before refusal at an elevation of 122 m (399 ft), which is interpreted as bedrock. The succession includes 5.2 m (17 ft) of yellowish brown sand and matrix-supported pebble gravel, overlying 5.2 m (17 ft) of pinkish yellowish brown interbedded sands and pebble gravels, overlying 9 m (30 ft) of red sands and pebble gravels, which extend to bedrock at elevation 130 m (428 ft). Fragments of pelecypod shells were recovered just above bedrock.

Discussion

The upland Core I-1083 penetrated a succession of Wisconsin Episode deposits, including 2.7 m (9 ft) of Peoria Silt (loess), 1.2 m (4 ft) of gray, loam-textured diamicton (Lemont Formation, Batestown Member), and 7 m (23 ft) of reddish brown loam diamicton (Tiskilwa Formation, undivided). The Tiskilwa till overlies 4.3 m (14 ft) of gray loam Illinois Episode diamicton (Glasford Formation, Radnor M.), which is weathered in its upper part (Sangamon Geosol), and 1.2 m (4 ft) of Illinois Episode sand and gravel (Pearl Formation).

Prior to drilling upland Core I-1083, the outcrop section had been interpreted as late Wisconsin Episode deposits of the Illinois River and Sandy Creek (Henry Formation). Discovery of Wisconsin Episode tills (Batestown Member and Tiskilwa Formation), an interglacial soil (Sangamon Geosol) and Illinois Episode till (Radnor Member) overlying the sand and gravel in the core indicates that the exposed deposits are all Illinois Episode or older. Thus, the Sandy Creek Section is the thickest outcrop of Illinois Episode AMR sand and gravel (Pearl Formation) in the Middle Illinois River valley area.

The absence of early and middle Illinois Episode diamictons (Kellerville and Hulick Members) indicates that both were eroded during one or more periods of incision. A single post-Hulick incision event may have eroded both. If so, much of the exposed sand and gravel dates to the middle Illinois Episode or later. Alternatively, the marked change in paleoflow direction in the sequence between Unit I and II could implicate that contact as the boundary between deposits of two distinct periods of Illinois Episode AMR valley fill. Given a number of boundaries in the succession, we have chosen the most significant in terms of numbers of characteristics that change across the unconformity. Thus, sand-and-gravel units above the change in paleoflow direction (Units II through IV) are tentatively correlated to the younger tongue of the Pearl Formation (tongue Pe-2), which underlies the late Illinois till (Radnor Member). Sand and gravel of Unit I is tentatively correlated to the older tongue of the Pearl Formation (tongue 1B), which underlies the middle Illinois Episode till (Hulick Member). The younger tongue (Pe-2) was also present at Stop 2-3 (Kettle), where it underlies late Illinois Episode diamicton (Radnor Member). The gravels at these two sites have similar compositions and flow directions consistent with the inferred correlation. The correlations are also consistent with elevations of scour and fill surfaces and with the occurrences of Illinois Episode diamictons in borings in the local area.

In Core I-1088 drilled below the base of the outcrop, the red sand is significantly different in composition from the overlying deposits. It has a uniquely low content of calcite and dolomite (Appendix B, Table B2-4b). Pelecypod shells were recovered from the lower 60 cm (2 ft) of the deposit, which rests on Pennsylvanian bedrock 20 m (64 ft) below the base of the exposure. These sands are correlated to the Sankoty Sand Member of the Banner Formation based on their similarity to sands that occur in the Schoepke No. 1 core, where the red sand is below the oldest Illinois Episode diamicton (Kellerville Member). If these Pearl Formation and Sankoty Sand Member correlations are correct, then the oldest tongue of the Pearl Formation (Pe-1A), which predates the early Illinois Episode diamicton (Kellerville Mbr.), is absent at Sandy Creek. We are hoping to improve correlations through further mineralogical characterization of the deposits and absolute age analyses via techniques, such as Optically Stimulated Luminescence (OSL) techniques, that appear to have the potential to date deposits such as those from Sandy Creek and the other AMV sites.

Figure 2-4C. Top: Unit IV (cobble-boulder gravel) overlying Unit III (massive, laminated, and ripple drift cross-laminated silts and sands) in the Sandy Creek Section, Stop 2-4.
Bottom: South-southeasterly dipping cross beds of Unit I described at the Sandy Creek Section. Shovel handle is 50 cm long.

REFERENCES

Berg, R.C., J.P. Kempton, L.R Follmer, and D.P. McKenna, 1985, Illinoian and Wisconsinan stratigraphy and environments in northern Illinois B: The Altonian revised: Illinois State Geological Survey Guidebook 19, 177 p.

Curry, B.B., 1998, Evidence at Lomax, Illinois, for mid-Wisconsin (~40,000 yr B.P.) position of the Des Moines Lobe and for diversion of the Mississippi River by the Lake Michigan Lobe (20,350 yr B.P.): Quaternary Science, v. 50, p. 128-138.

Curry, B.B., and L.R. Follmer, 1992, The last interglacial-glacial transition in Illinois, 123-25 ka, *in* P.U. Clark and P.D. Lea, editors, The Last Interglacial-Glacial Transition in North America: Boulder, Colorado, Geological Society of America Special Paper 270, p. 71-88.

Curry, B.B., and R.G. Baker, 2000, Palaeohydrology, vegetation, and climate since the late Illinois Episode (~130 ka) in south-central Illinois: Palaeogeography, Palaeoclimatology, and Palaeoecology, v. 155, p. 59-81.

Curry, B.B., and L.D. Delorme, 2003, Ostracode-based reconstruction from 23,300 to about 20,250 cal yr BP of climate and palehydrology of a groundwater-fed pond near St. Louis, Missouri: Journal of Paleolimnology, 29, p. 199–207.

Follmer, L.R., E.D. McKay, III, J.A. Lineback, and D.L. Gross, 1979, Wisconsinan, Sangamonian, and Illinoian stratigraphy in central Illinois: Illinois State Geological Survey Guidebook 13, 139 p.

Follmer, L.R., 1996, Loess studies in central United States: evolution and concepts: Engineering Geology, v. 45, no. 1-4, p. 287-304.

Forester, R.M., A. J. Smith, D. F. Palmer, and B. B. Curry (in review), NANONDe, North American Nonmarine Ostracode Database, Version 1, U.S. Geological Survey, Denver, Colorado.

Frankie, W.T., R.J. Jacobson, A.K. Hansel, and M.M. Killey, 2002, Guide to the geology of the Hennepin area, Putnam, Bureau, and Marshall Counties, Illinois: Illinois State Geological Survey Guidebook 2002A, 98p.

Frazee, C.J., J.B. Fehrenbacher, and W.C. Krumbein, 1970, Loess distribution from a source: Soil Science Society of America Proceedings, v. 43, p. 296-301.

Frye, J.C., Leon R. Follmer, H.D. Glass, J.M. Masters, and H.B. Willman, 1974, Earliest Wisconsinan sediments and soils: Illinois State Geological Survey Circular 485, 12 p.

Frye, J.C., H.B. Willman, and H.D. Glass, 1960, Gumbotil, accretion-gley, and the weathering profile: Illinois State Geological Survey Circular 295, 39p.

Glass, H.D., J.C. Frye, and H.B. Willman, 1964, Record of Mississippi River diversion in the Morton Loess of Illinois: Transactions, Illinois Academy of Sciences, v. 57, p. 24-27.

Glass, H.D., J.C. Frye, and H.B. Willman, 1968, Clay mineral composition, a source indicator of Midwest loess, in The Quaternary of Illinois: University of Illinois College of Agriculture Special Publication 14, p. 35-40.

Grimley, D.A., L.R. Follmer, and E.D. McKay, 1998, Magnetic susceptibility and mineral zonations controlled by provenance in loess along the Illinois and central Mississippi River valleys: Quaternary Research, v. 49, no. 1, p. 24-36.

Hajic, E.R., 1990, Late Pleistocene and Holocene landscape evolution, depositional subsystems, and stratigraphy in the Lower Illinois River Valley and adjacent Central Mississippi River Valley, Ph.D. dissertation, University of Illinois at Urbana-Champaign, 301 p.

Hallberg, G.R., and R.G. Baker, 1980, Reevaluation of the Yarmouth type area *in* G.R. Halberg, editor, Illinoian and Pre-Illinoian stratigraphy of southeastern Iowa and adjacent Illinois: Iowa Geological Survey Technical Information Series, no. 11, p. 111-150.

Hallberg, G.R., 1986, Pre-Wisconsinan glacial stratigraphy of the central plains region in Iowa, Nebraska, Kansas, and Missouri, *in* G.M. Richmond and D.S. Fullerton, editors, Quaternary glaciations in the United States of America: Quaternary Science Reviews, v. 5. p. 11-15.

Hansel, A.K., W.H. Johnson, and D.H. Voorhees, 1993, Subglacial till of deformation origin from the last glacial episode in central Illinois, Geological Society of America Abstracts with Programs, v. 25, no. 2, p. A-393.

Hansel, A. K., and W. H. Johnson, 1996, Wedron and Mason Groups: Lithostratigraphic Reclassification of Deposits of the Wisconsin Episode, Lake Michigan Lobe Area: Illinois State Geological Survey Bulletin 104, 116p.

Hansel, A.K., and A.J. Stumpf, 2003, Day 1: The Lake Michigan lobe in Illinois, *in* C.J. Patterson, A.K. Hansel, D.M. Mickelson., D.J. Quade, E.A. Bettis, III, P.M. Colgan, E.D. McKay, and A.J. Stumpf, Contrasting glacial landscapes created by ice lobes of the southern Laurentide Ice Sheet, *in* D.J. Easterbrook, editor, Quaternary Geology of the United States – INQUA 2003 Field Guide Volume, p. 135-139, Desert Research Institute, Reno, Nevada.

Hansel, A.K., and E.D. McKay III, in press, Quaternary Period, *in* D.R. Kolata, editor, The Geology of Illinois: Illinois State Geological Survey.

Horberg, C.L., 1950, Bedrock topography of Illinois: Illinois State Geological Survey Bulletin 73, 111p.

Horberg, C. L., 1953, Pleistocene deposits below the Wisconsin drift in northeastern Illinois: Illinois State Geological Survey Report of Investigations 165, 61p.

Horberg, C. L., T. E. Larson, and M. Suter, 1950, Groundwater in the Peoria region: Illinois State Geological Survey Bulletin 75, 128p.

Johnson, W.H., 1986, Stratigraphy and correlation of the glacial deposits of the Lake Michigan Lobe prior to 14 ka BP, *in* G.M. Richmond and D.S. Fullerton, editors, Quaternary glaciations in the United States of America: Quaternary Science Reviews, v. 5. p. 17-22.

Johnson, W.H., L.R. Follmer, D. L Gross, and A.M. Jacobs, 1972, Pleistocene stratigraphy of east-central Illinois: Illinois State Geological Survey Guidebook 9, 97 p.

Johnson, W.H., D.L. Gross, and S.R. Moran, 1971, Till stratigraphy of the Danville region, east-central Illinois, *in* R.P. Goldthwait, J.L. Forsyth, D.L. Gross, and F. Pessel, Jr., editors, Till, A Symposium: Ohio State University Press, Columbus, p. 184-216.

Karrow, P. F., A. Dreimanis, and P.J. Barnett, 2000, A proposed diachronic revision of late Quaternary time-stratigraphic classification in the eastern and northern Great Lakes area: Quaternary Research, v. 54, p. 1-12.

Kehew, A.E., and Lord, M.L., 1987, Glacial-lake outbursts along the mid-continent margins of the Laurentide Ice Sheet, in Catastrophic Flooding, L. Mayer, and D. Nash, eds., Boston, Allen & Unwin, p. 95-120.

Kemmis, T.J., D. Quade, A. Bettis, 1988, Hallett Gravel Pits, in Natural History of Ledges State Park and the Des Moines Valley in Boone County: Geological Society of Iowa Guidebook 48, p. 37-71.

Kempton, J.P., R.C. Berg, and L.R. Follmer, 1985, Revision of the stratigraphy of glacial deposits in central northern Illinois, *in* R.C. Berg, J.P. Kempton, L.R. Follmer, and D.P. McKenna, editors, Illinoian and Wisconsinan stratigraphy and environments in northern Illinois: the Altonian revisited: Illinois State Geological Survey Guidebook 19, p. 1-19.

Kempton, J.P., W.H. Johnson, P.C. Heigold, and K. Cartwright, 1991, Mahomet Bedrock Valley in east-central Illinois; Topography, glacial drift stratigraphy, and hydrogeology, *in* W.H. Melhorn and J.P. Kempton, editors, Geology and hydrogeology of the Teays-Mahomet Bedrock Valley system: Geological Society of America Special Paper 258, p. 91-124.

Kerasotes, M.L., 1989, Woodfordian stratigraphy and glacial geology in the upper Illinois Valley region, north central Illinois, M.S. thesis, University of Illinois at Urbana-Champaign, 166 p.

Leigh, D.S., and J.C. Knox, 1994, Loess of the upper Mississippi Valley driftless area: Quaternary Research, v. 42, p. 30-40.

Leighton, M.M., 1926, A notable type Pleistocene section: The Farm Creek exposure near Peoria, Illinois: Journal of Geology, v. 34, p. 167-174.

Leighton, M.M., 1931, The Peorian loess and classification of the glacial drift sheets of the Mississippi Valley: Journal of Geology, v. 39, p. 45-53.

Leighton, M.M., 1933, The naming of the subdivisions of the Wisconsin glacial age: Science, v. 77, no. 1989, p. 168.

Leighton, M.M., and H.B. Willman, 1950, Loess formations of the Mississippi Valley: Journal of Geology, v. 58, p. 599-623.

Lineback, J.A., 1979a, Quaternary deposits of Illinois (Map): Illinois State Geological Survey, scale 1:500,000.

Lineback, J.A., 1979b, The status of the Illinoian glacial stage, *in* L.R. Follmer, E.D. McKay, J.A. Lineback, and D.L. Gross, editors, Wisconsinan, Sangamonian, and Illinoian stratigraphy in central Illinois: Illinois State Geological Survey Guidebook 13, p. 69-78.

McComas, M. R., 1968, Geology related to land use in the Hennepin region: Illinois State Geological Survey Circular 422, 24p.

McComas, M.R., 1969, Pleistocene geology and hydrogeology of the Middle Illinois Valley, Ph. D. thesis, University of Illinois, 130 p.

McKay, III, E.D., 1977, Stratigraphy and zonation of Wisconsinan loesses in southwestern Illinois: Ph.D. thesis, University of Illinois at Urbana-Champaign, 241 p.

McKay, E.D., 1979, Stratigraphy of Wisconsinan and older loesses in southwestern Illinois, *in* J.D. Treworgy, E.D. McKay, III, and J.T. Wickham, editors, Geology of western Illinois, 43rd Annual Tri-State Geological Field Conference 43: Illinois State Geological Survey Guidebook 14, p. 37-67.

McKay III, E.D., R.C. Berg, A.J. Stumpf, and C.P. Weibel, in press, Surficial Geology of the Middle Illinois River Valley: Illinois State Geological Survey Map, scale 1:48,000.

Miall, A.D., 1977, A Review of the Braided River Depositional Environment: Earth-Science Reviews, v. 13, p. 1-62.

Miall, A.D., 1985, Architectural-Element Analysis: A New Method of Facies Analysis Applied to Fluvial Deposits: Earth-Science Reviews, v. 22, p. 261-308.

Nelson, R.S., D.H. Malone, W.E. Shields, and R.G. Corbett, 2002, Sandy Creek Section of the Henry Formation, in W.T. Frankie, R.J. Jacobson, A.K. Hansel, and M.M. Killey, Guide to the geology of the Hennepin area, Putnam, Bureau, and Marshall Counties, Illinois: Illinois State Geological Survey Field Trip Guidebook, 2002A, p. 91-98.

Patterson, CJ., A.K. Hansel, D.M. Mickelson., D.J. Quade, E.A. Bettis, III, P.M. Colgan, E.D. McKay, and A.J. Stumpf, Contrasting glacial landscapes created by ice lobes of the southern Laurentide Ice Sheet, *in* D.J. Easterbrook, editor, Quaternary Geology of the United States – INQUA 2003 Field Guide Volume, p. 135-139, Desert Research Institute, Reno, Nevada.

Stumpf, A.J., and C.P. Weibel, 2005, Surficial geology of Spring Bay Quadrangle, Peoria and Woodford Counties, Illinois: Illinois State Geological Survey, IGQ Spring Bay SG, 1:24,000.

Walker, W.H., R.E. Bergstrom, and W.C Walton, 1965, Preliminary Report on the Ground-Water Resources of the Havana Region in West-Central Illinois: Illinois State Water Survey - Illinois State Geological Survey Cooperative Ground-Water Report 3, 61 p.

Weibel, C. P., D. A. Keefer, E. D. McKay, and R. C. Berg, 2005, Bedrock Topography Map of the Middle Illinois River Valley Region: Illinois State Geological Survey Map, scale 1:48,000.

Weibel, C.P., and A.J. Stumpf, 2001, Geologic mapping along the Illinois River: in proceedings of the 2001 Governor's Conference on the Management of the Illinois River System, Eighth Biennial Conference, October 2-4, 2001, p. 240.

Wickham, S.S., 1975, The Tiskilwa till member, Wedron Formation; A regional study in northeastern Illinois: Unpublished M.S. thesis, University of Illinois, Urbana-Champaign, 213 p.

Wickham, J.T., 1979, Pre-Illinoian till stratigraphy in the Quincy, Illinois, area, *in* J.D. Treworgy, E.D. McKay, and J.T. Wickham, editors, Geology of western Illinois: Tri-State Geological Field Conference 43: Illinois State Geological Survey Guidebook 14, p. 69-90.

Willman, H. B., and J. C. Frye, 1970, Pleistocene Stratigraphy of Illinois: Illinois State Geological Survey Bulletin 94, 204p.

APPENDIX A - Quaternary Stratigraphy

Lithostratigraphic classifications and terminology used herein follow those of Hansel and Johnson (1996) for the Wisconsin Episode and Willman and Frye (1970) for older deposits. Stratigraphic units that occur in the AMV in central Illinois are discussed in order from oldest to youngest. Refer also to Figures 3 and 4.

PRE-ILLINOIS EPISODE

Banner Formation, Sankoty Sand Member - The oldest Quaternary deposit in the area, the Sankoty Sand Member (Figs. 3 and 4), was defined by Horberg (1950) and interpreted as a fluvial deposit of early Pleistocene or preglacial age. Willman and Frye (1970) included the Sankoty as a member of the "Kansan" age Banner Formation and noted that the Sankoty Sand Member "is not known to have a soil on it where it is overlain by Kansan age till. They indicated "it is more likely pro-Kansan outwash." The Sankoty sand has been widely mapped along the AMV (Horberg et al. 1950; McComas 1968).

The Sankoty Sand Member, which has a distinctive "pinkish" color, ranges in texture from medium to coarse-grained sand but locally ranges from silty fine sand to very coarse sand and granule gravel. It is more than 75 percent quartz, of which 10-20 percent are pink, clear, polished and rounded (Horberg et al. 1950, Walker et al. 1965). The pink color is attributed to reddish (hematite) stain on the sand grain surfaces. The remaining 25 percent of the sand grains are composed of nearly equal proportions of feldspar and crystalline and sedimentary rocks. Coarser fractions of the unit (gravel > 4 mm) are composed predominantly of dolomite (Walker et al. 1965). Horberg (1953) reported that the Sankoty Sand averages 30 m (100 ft) thick and reaches as much as 90 m (300 ft) where deep bedrock valleys underlie the uplands.

A pre-glacial age for any of the valley-fill sand and gravel in the AMV is not clearly demonstrated by available evidence. A pre-Illinois Episode age for these deposits is suggested but not proven. Neither we nor previous workers (e.g. Horberg 1953, McComas 1968) have identified a Yarmouth Geosol in the study area. No age determinations have been done on the unit.

Although our observations are limited to a fraction of the area of occurrence of the Sankoty Sand Member mapped by Horberg et al. (1950) and McComas (1968), we have confirmed Horberg's observation that the AMV fill is a complex of several successions interrupted by glaciations. Our work is beginning to show that those successions can be identified and distinguished with detailed data, if not mapped. Recent drilling and mapping in the AMV between Hennepin and Chillicothe suggest that the Sankoty sand, as previously mapped, includes what we now think are inset valley-fill units composed of significant thicknesses of Illinois and Wisconsin Episode deposits.

The pink-colored sands are not as age-restricted as once thought and, in fact, occur in units that overlie Illinois Episode diamictons. The color and mineralogy of the “Sankoty-type” sands may be attributed more to a particular provenance than to a particular age deposit. Therefore, we attribute the red hue and distinct composition of the Sankoty-type sand to source areas in the upper Mississippi watershed northwest of Illinois. We attribute the dolomitic outwashes to meltwater from glaciers in the Lake Michigan basin that entrained large amounts of dolomite.

These questions of complexity, composition, and correlation have practical importance, because the “Sankoty Aquifer”, a prolific aquifer in some areas, is much less productive in others. Far from being homogenous and regionally predictable, the Sankoty Aquifer is a succession of complex compartmentalized fluvial deposits interbedded with glacial diamictons and lacustrine deposits, which account for highly variable water yields and quality.

ILLINOIS EPISODE

Pearl Formation– Outwash sand and gravel related to Illinois Episode glaciation is thick and widespread in the AMV of central Illinois. These deposits are included in the Pearl Formation and subdivided to a greater degree than the original definition of the unit (Figs. 3 and 4). Willman and Frye (1970) defined the Pearl Formation as deposits that overlie or extend beyond Illinoian till. Glaciofluvial deposits that underlie and interfinger with the Illinois Episode diamictons were recognized as being continuous into the Pearl Formation, but in nomenclature were separated from it by a stratigraphic convention, the vertical cutoff. Such deposits were included as part of the till and intratill members of the Glasford Formation (Willman and Frye 1970). For this report, we depart from that usage by recognizing the major sand and gravel deposits beneath and between Illinois Episode diamictons of the Glasford Formation as continuous with the Pearl Formation beyond the glacial margin and treat them nomenclaturally as informal tongues of the Pearl Formation. From the base upward, they are tongues, Pe-1A, Pe-1B, and Pe-2. The surficial Illinois Episode outwash sand and gravel (designated Pe-3) is entirely a subsurface unit in the field trip area. These units range from fine sand to boulder gravel and include sedimentary clasts of local origin as well as abundant erratic lithologies. Where Illinois Episode diamictons, the Sangamon Geosol and the Wisconsin Episode loesses are absent, Pearl Formation sand and gravel may be indistinguishable from younger, Wisconsin Episode sands and gravels. Relations of the four Pearl tongues to the Illinois Episode diamictons are shown in Figures 3 and 4.

Pearl Formation, tongue Pe-1A – Tongue Pe-1A overlies the Sankoty Sand Member or older deposits and is overlain by diamicton of the Kellerville Member of the Glasford Formation. In parts of the AMV, the Pearl Fm. is the principal sand and gravel deposit present, the underlying Sankoty Member, having been largely reworked and/or eroded during deposition of the Pearl sand. The Pearl tongue present in a particular succession is defined by the diamicton that overlies it; Pe-1A by the Kellerville Member, Pe-1B by the Hulick Member, and Pe-2 by the Radnor Member. We are working to develop mineralogical and field criteria to allow the tongues to be distinguished in the absence of the intervening diamictons.

Glasford Formation, Kellerville Member - The oldest glacial diamicton confirmed in the study area, the Kellerville Member of the Glasford Formation (Figs. 3 and 4), is mapped only in the subsurface. It is a grayish brown to gray, silty clay loam diamicton that is dolomitic and contains a higher percentage of expandable clay minerals than other Illinois Episode diamictons. The proportion of expandable clay minerals in this diamicton has been found to increase westward toward the ice margin in eastern Iowa (Willman and Frye 1970). The Kellerville Member has limited extent within the MIBV, having been incised during later Illinois and Wisconsin Episode fluvial events that deepened and widened the valley. The Kellerville Member was deposited by glaciers from the Lake Michigan basin. The diamicton overlies the Sankoty Sand Member or Illinois Episode outwash, correlated here to tongue Pe-1A of the Pearl Formation. A paleosol described in western Illinois developed in the Kellerville Member, the Pike Geosol, has not been observed in the MIV.

Pearl Formation, tongue Pe-1B – Sand and gravel of tongue Pe-1B (Figs. 3 and 4) overlies the Kellerville Member of the Glasford Formation or older deposits and is overlain by diamicton of the Hulick Member of the Glasford Formation.

Glasford Formation, Hulick Member – A grayish brown to gray, loam-textured diamicton, the Hulick Member (Figs. 3 and 4) is exposed at the surface along Rattlesnake Hollow in southern Marshall County and in several locations along Illinois Route 18 east of the town of Henry in Putnam Co. This diamicton contains more dolomite and illite and a lower proportion of expandable clay minerals than the underlying Kellerville Member. It has a coarser texture and lower illite content than the overlying Radnor Member. The Hulick Member in the MIV contains abundant clasts of the local bedrock, particularly coal. The diamicton is considered the lateral equivalent of the Vandalia Member in south central Illinois and, in the AMV forms a thick, widespread deposit. The Hulick Member is particularly thick near the margins of the MIBV, but the unit is less continuous near the axis of the valley, where it was eroded during later Illinois and Wisconsin Episode fluvial events. An exception is a remnant of the Illinois Episode upland preserved east of Henry along Route 18, which will be visited on Day 2 of this field trip. Here the diamicton contains evidence of ice-collapse. The Hulick Member overlies Illinois Episode outwash (correlated here to the informal tongue Pe-1B of the Pearl Formation), older sediments, or bedrock.

Pearl Formation, tongue Pe-2 – Sand and gravel of tongue Pe-2 overlies the Hulick Member of the Glasford Formation or older deposits and is overlain by diamicton of the Radnor Member of the Glasford Formation (Figs. 3 and 4).

Glasford Formation, Radnor Member – The Radnor Member, stratigraphically is the uppermost Illinois Episode diamicton in central Illinois. It is a gray silty clay loam to loam diamicton with the Sangamon Geosol commonly developed in its upper part (Figs. 3 and 4). The diamicton is texturally finer grained and contains more illite than other Illinois Episode diamictons and contains interbedded sand, gravel, and silt, particularly in its upper part. It commonly contains clasts of the local bedrock. It is continuous in the subsurface beneath the upland along the AMV, but is typically not present in the

central part of the MIBV where it has been eroded by later fluvial and glacial events. The Radnor Member overlies Illinois Episode outwash, correlated here to the informal tongue Pe-2 of the Pearl Formation or older sediments. It is overlain by tongue Pe-3 of the Pearl Formation or younger deposits.

Pearl Formation, tongue Pe-3 – Tongue Pe-3 (Figs. 3 and 4) represents the uppermost subdivision of the deposit and its stratigraphic position most closely correlates with the original definition of the Pearl Fm. of Willman and Frye (1970). It is designated as a tongue to distinguish it from the several other elements of the Pearl Fm. Tongue Pe-3 overlies the Radnor Member or older deposits and has the Sangamon Geosol in its upper part.

Sangamon Geosol - The Sangamon Geosol (Fig. 2 formed on the glacial and fluvial landscape left by retreating Illinois Episode glaciers over 120,000 years ago. The Sangamon Geosol displays a wide range of soil characteristics dependent upon its parent material and the prevailing drainage, vegetation, and slope conditions during soil development. The Sangamon profile is commonly leached of carbonates to a depth of 1.5 to 2 m or more. The solum has a well developed Bt and displays an A and E horizons in many locations. It is typically developed in the upper part of the youngest Illinois Episode deposits, i.e. the Radnor Member diamicton or sand and gravel of tongue Pe-3 of the Pearl Formation across wide areas of upland central Illinois. Near the AMV, where the soil developed in eroded uplands, the type of parent material can change over short distances.

Roxana Silt – The Roxana Silt (Figs. 2, 3 and 4) is a middle Wisconsin Episode deposit present along the AMV in central Illinois and along the Mississippi River as far south as southeastern Arkansas. Studies of the Roxana Silt elsewhere have demonstrated that the Roxana Silt is a loess, traceable as a distinct unit along the AMV from Minnesota to Mississippi (Leigh 1994; Follmer 1996), and the main body of the unit was deposited between about 55,000 and 28,000 ^{14}C yr BP (McKay 1979; Curry and Follmer 1992; Leigh 1994; Hansel and Johnson 1996). In the MIV area, the Roxana Silt is a thin, less than 3 m (10 ft), deposit of reddish brown to gray, slightly calcareous silt loam, usually leached in its upper and lower parts. At its base, it conformably merges with and overlies the Sangamon Geosol. Several weathered zones and silt deposits in the lower Roxana have been distinguished from the main body of the unit (Willman and Frye 1970, Curry and Follmer 1992). Color zones within the unit reflect a combination of provenance and weathering. Red color in the lower part is related to reddish sediment carried by the AMR from its headwaters in Minnesota and Wisconsin (Grimley et al. 1998). The grayer, more illitic, and more dolomitic, middle interval of the unit is composed of debris eroded by glaciers flowing over Paleozoic-age shales and dolomites mapped further south in the watershed. A brief hiatus in loess deposition from about 28,000 to 25,000 ^{14}C yr BP is marked by the weakly developed Farmdale Geosol.

The Robein Silt Member of the Roxana Silt, is an organic silt or peat, typically leached of carbonate, that includes the profile of the Farmdale Geosol. The Robein Silt is a regional stratigraphic marker unit, which was the source for the majority of woody debris that was eroded and incorporated into the Wisconsin Episode glaciers. Organic carbon (^{14}C) age

determinations on the Robein and Roxana range from >45,000 to about 20,000 ^{14}C yr BP in the MIV. Because a significant amount of organic material from the Robein Silt was entrained into the Wisconsin Episode ice, spurious old ages have been obtained, which complicate the interpretation of radiocarbon age determinations, particularly on wood in the valley fill and diamicton sediments of the MIV area.

Farmdale Geosol – The Farmdale Geosol, as noted above, is a weakly expressed paleosol formed in the Roxana Silt along the AMV during a period when loess deposition slowed or ceased briefly (Fig. 2). In near-valley locations where loess was thick, the Farmdale Geosol is separated from the upper solum of the Sangamon Geosol by up to several meters of calcareous loess. Farther from the valley, where deposits are thinner, the Farmdale and upper Sangamon profiles merge.

Peoria Silt, Morton Tongue – The Morton Tongue is a silt (loess) deposit of up to 3 m (10 ft) thick that is locally exposed. The dolomitic silt is gray, brownish gray, or yellowish brown and has a silt to silt loam texture. The Morton Tongue is equivalent to the lowermost part of the Peoria Silt beyond the margin of the Wisconsin Episode glacial deposits (Hansel and Johnson 1996). The base of this unit has been consistently dated at about 24,500 to 25,000 ^{14}C yr BP along the AMV. The silt accumulated adjacent to the valley until the glacier from the Lake Michigan basin reached the area about 20,350 ^{14}C yr BP. Beyond the Wisconsin margin, a distinct change in mineralogy in the lower part of the Peoria Silt, first identified by Glass et al. (1968), marks the diversion of the AMR in the stratigraphic record.

Where present, the Roxana Silt, the Robein Silt Member, the Morton Tongue, and the Sangamon Geosol are marker beds that are particularly useful for interpreting the complex stratigraphic succession of the area. Peat and organic silt are commonly noted in drillers' logs.

Henry Formation, Ashmore Tongue - Sand and gravel deposits of the Ashmore Tongue (Figs. 3 and 4) fill much of the AMV in some areas. The unit includes sand and gravel in the main channels of the AMR that were deposited during the Wisconsin Episode (Hansel and Johnson 1996) and overridden by the glacier depositing the Tiskilwa Formation. These deposits have been previously interpreted as part of the Sankoty Sand Member (Horberg et al. 1950, Horberg 1953, McComas 1968). Where it can be demonstrated that the AMR reworked and eroded much of the older valley-fill sediment during the Wisconsin Episode, we classify its deposits as Ashmore Member rather than Sankoty Sand Member or Pearl Formation. In these areas the Tiskilwa Formation lies directly above this unit with no intervening Illinois Episode diamictons. More field study and laboratory analysis are needed to consistently distinguish the Ashmore Tongue from the Pearl Formation and Sankoty Sand Member. The Ashmore Tongue is a significant component of the regional aquifer that occupies the MIBV.

Tiskilwa Formation – The widespread Tiskilwa Formation is distinctive reddish brown to gray, loam textured diamicton lying at the surface and in the subsurface in the MIV (Figs. 3 and 4). The diamicton is extremely thick, exceeding 45 m (150 ft) in the field trip area. To the south in the uplands along the MIV, the Tiskilwa Formation has a maximum thickness of approximately 100 m (330 ft). Throughout the Tiskilwa diamicton, thin beds of sand and gravel or silt are common. Locally, beds of bouldery diamicton, possibly colluvium, have been mapped. Where the lower part of the Tiskilwa diamicton is silty and organic rich, the **Oakland facies** (Hansel and Johnson 1996) is differentiated, but has not mapped separately in the AMV. The lower part (5 to 25 feet) of the diamicton, where it is gray to greenish gray is correlated with the **Delavan Member**. The upper 5 to 15 feet of the Tiskilwa Formation, where it is grayish brown to gray, loam textured diamicton, is referred to as the **Piatt Member**. In exposures the Delavan diamicton can be misinterpreted as older (Illinois Episode) Radnor or Hulick diamictons, which resemble it in color, although the Hulick and Radnor Members contain more coal fragments, and the Radnor Member has a finer texture. The Delavan Member and both Illinois Episode diamictons seldom contain large quantities of wood characteristic of the Oakland facies.

In the MIV, the Tiskilwa Formation forms part of a composite end moraine complex including the Bloomington Morainic System (Plate 2, Fig. 1). Its significant thickness and the presence of outwash and colluvial interbeds are characteristics of a moraine developed during multiple readvances causing debris stacking, interrupted by periodic standstills or ice retreats. The MIV lies approximately 16 km (10 mi) from the maximum extent of Wisconsin Episode ice, and therefore it is possible that the glacier margin melted back to a position east of the valley before readvancing. Evidence for readvances will be observed at the Clear Creek (Stop 1-1) and Rattlesnake Hollow (Stops 1-3, 1-5, and 1-6) sections.

Henry Formation, Dry Creek tongue - Sand and gravel deposits between the Tiskilwa Formation and the overlying Batestown Member are referred to informally as the Dry Creek tongue of the Henry Formation (Figs. 3 and 4) in exposures in a large borrow pit along Dry Creek, SW NW Section 11, T. 29 N., R. 2 W, Woodford County, where the unit consists of up to 12 feet of pebble gravel and coarse sand. The unit is widespread and sheet-like in the subsurface beneath upland areas, does not appear to fill a former course of the AM River, and forms a local shallow aquifer.

Lemont Formation, Batestown Member – An olive brown to gray, loam-texture diamicton, the Batestown Member (Figs. 3 and 4) overlies the Tiskilwa Formation and/or the Dry Creek tongue of the Henry Formation beneath most upland areas. Its westward limit is approximately delineated by the northwest-southeast trending Eureka Moraine (Plate 2, Fig. 1) along the western part of the MIV. Batestown diamicton has locally been mapped to the west of the Eureka Moraine. Beyond this ice margin, the Tiskilwa Formation forms the surface till.

Lemont Formation, Yorkville Member – The Yorkville Member comprises an olive brown to gray, silty clay loam-textured diamicton that overlies the Batestown Member east of the MIV. Regionally, tongues of sand and gravel and/or

silt and clay separate the two members. The westward limit of the diamicton coincides approximately with the north-south trending Varna Moraine (Plate 2, Fig. 1).

Peoria Silt - Silt blankets most of the upland areas to a depth of 5 to 15 feet and is thickest on uplands near its source, the Illinois River valley. Thin, discontinuous loess deposits have been mapped on the upper surfaces of some high terraces in the MIV.

Henry Formation, Mackinaw facies – These surficial sand and gravel deposits compose large terraces in the MIV and some smaller terraces in tributary valleys to the Illinois. These were deposited largely by meltwater from the Lake Michigan glacial lobe when it stood in the upper Illinois River watershed. Some thin outwash deposits have also been mapped on the uplands and represent local fluvial deposition from a former glacier margin.

APPENDIX B – Analytical Data

Analytical data for samples collected for this report are shown in tables numbered as follows A (for Appendix) 1-1 (stop number). The following abbreviations and symbols are used:

SplNo =	sample number	Silt =	.004 to .062 mm (percent)
ElevTop =	elevation of sample top (ft)	Clay =	<.004 mm (percent)
Cc =	calcite in counts per second (cps)	-- =	not determined
D =	dolomite (cps)	14C yr BP	
Cc* =	calcite as percent of bulk sample	cal yr BP	
D* =	calcite as percent of bulk sample	Q2* = quartz as percent of bulk sample	
E =	expandable clay minerals (percent)	Kf* = orthoclase feldspar as percent of bulk sample	
I =	illite (percent)	Pf* = plagioclase feldspar as percent of bulk sample	
K+C =	kaolinite plus chlorite (percent)	H* = hornblende as percent of bulk sample	
Sand =	.062 to 2 mm (percent)	Py* = pyroxene as percent of bulk sample	

Table B1-1. Clay Mineral and Particle Size Data by Stratigraphic Unit for Stop 1-1, the Clear Creek Section.

SplNo	Cc	D	E	I	K+C	Sand	Silt	Clay	Lithology	Lithostratigraphic unit
cd-17-1	5	29	10	74	16	44	48	8	diamicton, stratified	Batestown M.
cd-17-2	3	31	2	74	24	44	41	15	diamicton	Batestown M.
cd-17-3	3	30	2	74	24	41	42	17	diamicton	Batestown M.
cd-17-4	4	32	1	75	24	47	39	14	diamicton	Batestown M.
cd-17-5	2	34	1	71	28	56	36	8	diamicton	Batestown M.
hg-59-4	--	--	3	79	18	--	--	--	diamicton	Batestown M.
mean	*3*	*31.75*	*1.8*	*74.6*	*23.6*	*47*	*39.5*	*13.5*		
std dev	*0.70*	*1.47*	*0.74*	*2.57*	*3.2*	*5.61*	*2.29*	*3.35*		
cd-17-6	3	35	5	67	28	50	39	11	diamicton	Piatt M., Tisk. Fm.
cd-17-7	5	35	3	68	28	50	38	12	diamicton	Piatt M., Tisk. Fm.
cd-17-8	4	28	4	69	27	54	33	13	diamicton	Piatt M., Tisk. Fm.
cd-17-9	2	43	3	71	26	45	42	13	diamicton	Piatt M., Tisk. Fm.
cd-17-10	4	39	4	69	27	50	38	12	diamicton	Piatt M., Tisk. Fm.
cd-18-2	5	46	3	70	27	56	32	12	diamicton	Piatt M., Tisk. Fm.
cd-18-3	15	33	4	69	27	51	36	13	diamicton	Piatt M., Tisk. Fm.
cd-18-4	2	35	3	70	27	43	44	13	diamicton	Piatt M., Tisk. Fm.
hg-59-5	3	--	4	74	22	--	--	--	diamicton	Piatt M., Tisk. Fm.
mean	*4.78*	*36.75*	*3.67*	*69.67*	*26.56*	*49.88*	*37.75*	*12.38*		
std dev	*3.76*	*5.36*	*0.67*	*1.89*	*1.71*	*3.98*	*3.83*	*0.70*		

cd-17-11	4	37	8	64	28	43	37	20	diamicton	Tiskilwa Fm.
cd-17-12	4	26	13	60	27	45	40	15	diamicton	Tiskilwa Fm.
cd-18-5	4	27	14	61	25	45	41	14	diamicton	Tiskilwa Fm.
cd-18-6	5	30	10	63	27	42	37	21	diamicton	Tiskilwa Fm.
cd-18-7	6	24	14	58	28	40	42	18	diamicton	Tiskilwa Fm.
cd-18-8	4	22	13	60	27	41	38	21	diamicton	Tiskilwa Fm.
cd-18-9	7	27	13	62	25	39	39	20	diamicton	Tiskilwa Fm.
cd-18-10	5	31	13	62	25	39	35	26	diamicton	Tiskilwa Fm.
cd-18-11	6	22	12	64	24	40	39	21	diamicton	Tiskilwa Fm.
cd-18-12	4	26	18	57	25	38	45	17	diamicton	Tiskilwa Fm.
hg-59-6	--	--	22	59	19	--	--	--	diamicton	Tiskilwa Fm.
hg-59-7	--	--	14	61	25	--	--	--	diamicton	Tiskilwa Fm.
hg-59-10	--	--	19	58	23	--	--	--	diamicton	Tiskilwa Fm.
dv-34	--	--	12	55	33	38	45	16	diamicton	Tiskilwa Fm.
dv-33	--	--	9	53	38	33	48	20	diamicton	Tiskilwa Fm.
dv-32	--	--	8	57	36	32	47	21	diamicton	Tiskilwa Fm.
dv-31	--	--	8	53	39	38	48	14	diamicton	Tiskilwa Fm.
dv-42	--	--	7	56	37	38	41	21	diamicton	Tiskilwa Fm.
dv-41	--	--	6	56	38	38	42	19	diamicton	Tiskilwa Fm.
dv-40	--	--	4	55	40	41	41	18	diamicton	Tiskilwa Fm.
mean	*4.90*	*27.20*	*11.85*	*58.70*	*29.45*	*39.41*	*41.47*	*18.94*		
std dev	*1.04*	*4.31*	*4.40*	*3.35*	*6.18*	*3.38*	*3.84*	*3.00*		
dv-39	--	--	24	41	35	25	54	21	diamicton	Delavan M., Tisk. Fm
dv-38	--	--	20	43	37	26	52	22	diamicton	Delavan M., Tisk. Fm
dv-37	--	--	20	44	37	26	53	21	diamicton	Delavan M., Tisk. Fm
mean	--	--	*21.33*	*42.67*	*36.33*	*25.67*	*53.00*	*21.33*		
std dev	--	--	*1.89*	*1.25*	*0.94*	*0.47*	*0.82*	*0.47*		
cd-17-13		32	17	58	25	39	31	30	diamicton	Oakland facies, Tisk. Fm.
cd-17-14		18	18	57	25	33	37	30	diamicton	Oakland facies, Tisk. Fm.
cd-17-15		13	24	52	24	18	66	16	diamicton with organic lens	Oakland facies, Tisk. Fm.
cd-18-1	2	12	28	49	23	28	49	23	diamicton	Oakland facies, Tisk. Fm.
cd-18-13	2	15	33	47	20	24	67	9	diamicton	Oakland facies, Tisk. Fm.
cd-18-14	18	16	10	52	38	23	56	21	diamicton lens, green	Oakland facies, Tisk. Fm.
cd-18-15	1	9	24	54	22	20	70	10	diamicton	Oakland facies, Tisk. Fm.
hg-59-9	--	--	36	42	22	--	--	--	diamicton, woody	Oakland facies, Tisk. Fm.
hg-59-11	--	--	28	49	23	--	--	--	diamicton lens, greenish gray	Oakland facies, Tisk. Fm.

hg-59-12	--	--	46	40	14	--	--	--	diamicton lens, clayey red	Oakland facies, Tisk. Fm.
dv-18	3	--	39	28	33	9	84	8	diamicton	Oakland facies, Tisk. Fm.
dv-50	4	--	21	40	39	23	62	15	diamicton lens, gray	Oakland facies, Tisk. Fm.
dv-47	2	--	0	38	62	19	55	26	diamicton lens, green	Oakland facies, Tisk. Fm.
dv-51	--	--	0	45	54	18	43	38	diamicton lens, red clay	Oakland facies, Tisk. Fm.
mean	*4.57*	*16.43*	*23.14*	*46.50*	*30.29*	*23.09*	*56.36*	*20.55*		
std dev	*5.55*	*6.90*	*13.09*	*7.99*	*13.15*	*7.70*	*14.90*	*9.40*		

cd = particle size by Christine Dellaria, clay minerals by Adam Ianno
hg = clay minerals by Herbert Glass
dv = particle size and clay minerals by David Voorhees

Table B1-2a. Clay Mineral and Particle Size Data for Stop 1-2, the Friday3 Section.

SplNo.	ElevTop	Cc*	D*	E	I	K+C	Sand	Silt	Clay	Lithology	Color	Lithostratigraphic Unit
A	555	7	34	11	66	23	11	80	9	silt	tan	tongue, Equality Fm
B	552	9	48	6	63	31	16	72	12	silt and fine sand	tan	tongue, Equality Fm.
C	551	5	25	13	59	27	40	42	18	sandy diamicton	beige	Tiskilwa Fm., Piatt M.
D	549	5	22	11	61	28	39	40	21	diamicton	tan	Tiskilwa Fm., Piatt M.
E	545	4	36	12	62	26	39	40	21	diamicton	tan	Tiskilwa Fm., Piatt M.

Table B1-2b. Percentage of ostracode species sampled at the Friday3 Section from the upper facies, unnamed tongue of the Equality Formation.

Species Name	Number	% of Total
Cyclocypris sharpei	261	57.5
Cyclocypris ampla	81	17.8
Fabaefiscandona rawsoni	38	8.4
Cypridopsis vidua	24	5.3
Potamocypris smaragdina	20	4.4
Limnocythere friabilis	15	3.3
Candona paraohioensis	5	1.1
Candona candida	6	1.3
Cypricercus tuberculatus	2	0.4
Limnocythere herricki	1	0.2
Ilyocypris gibba	1	0.2
total	454	100

Table B1-3. XRD analyses of clay and grain-size (hydrometer) analyses for Stop 1-3, the Rattlesnake Hollow - West Section.

SplNo.	ElevTop	Cc	D	E	I	K+C	Sand	Silt	Clay	Lithology	Lithostratigraphic unit
A	593.0	22	35	19	67	14	33	35	32	diamicton	Tiskilwa Fm. - undivided
B	590.0	15	28	23	60	17	37	37	26	diamicton	Tiskilwa Fm. - undivided
C	584.5	--	--	--	--	--	--	--	--	sand and gravel	Tiskilwa Fm. - undivided
D	583.0	22	30	12	66	23	42	32	26	diamicton	Tiskilwa Fm. - undivided
E	580.5	19	28	12	66	23	43	32	25	diamicton	Tiskilwa Fm. - undivided
F	576.0	15	26	14	64	23	44	32	24	diamicton	Tiskilwa Fm. - undivided
G	571.0	--	--	--	--	--	--	--	--	diamicton	Tiskilwa Fm. - undivided
H	569.5	--	--	--	--	--	--	--	--	gravel	Henry Fm., Ashmore M.
I	564.0	--	--	--	--	--	--	--	--	sand	Henry Fm., Ashmore M.
J1	562.5	0	0	45	44	12	26	62	12	diamicton	Henry Fm., Ashmore M.
J2	561.5	0	0	55	35	11	0	89	11	lacustrine silt	Henry Fm., Ashmore M.
K	555.0	0	0	65	27	9	3	80	17	silt	Roxana Silt
L	553.0	0	0	49	30	22	49	31	20	sandy silt	Roxana Silt
M	551.0	0	0	25	49	27	65	17	18	loamy sand	Pearl Fm.

Table B1-5. XRD analyses of clay and grain size (hydrometer) analyses for stop 1-5, the Rattlesnake Hollow - Middle Section.

SplNo.	ElevTop	Cc	D	E	I	K+C	Sand	Silt	Clay	Lithology	Lithostratigraphic unit
X-295-6	568.00	29	36	12	75	13	48	31	21	diamicton	Tiskilwa Fm. - undivided
X-295-5	563.00	27	32	8	70	22	--	--	--	diamicton	Tiskilwa Fm. - undivided
X-295-4	543.25	0	13	32	55	13	15	75	10	silt	Pearl Fm.
X-295-7	541.00	10	18	23	52	25	17	45	38	diamicton	Glasford Fm., Kellerville M.
X-295-3	541.00	9	11	40	42	18	16	53	31	diamicton	Glasford Fm., Kellerville M.
X-295-2	535.00	0	0	40	41	19	20	45	35	diamicton	Glasford Fm., Kellerville M.
X-295-8	533.00	11	0	60	24	16	10	46	44	diamicton	Glasford Fm., Kellerville M.
X-295-1	532.00	0	0	38	39	23	13	53	34	diamicton	Glasford Fm., Kellerville M.

Table B1-6. XRD analyses of clay and grain size (hydrometer) analyses for Stop 1-6, the Rattlesnake Hollow - East Section.

SplNo.	ElevTop	Cc	D	E	I	K+C	Sand	Silt	Clay	Lithology	Lithostratigraphic unit
B12	577.00	37	40	19	68	13	40	33	27	diamicton	Tiskilwa Fm., undivided
B11	573.00	16	29	20	67	13	44	34	22	diamicton	Tiskilwa Fm., undivided
B10	571.50	37	42	10	67	23	38	35	27	diamicton	Tiskilwa Fm., undivided

B9	558.25	9	16	13	68	19	26	50	24	diamicton	Tiskilwa Fm., Delavan M.
B8	554 50	10	17	9	69	22	24	51	25	diamicton	Tiskilwa Fm., Delavan M.
B7	552.00	11	18	9	69	22	24	51	25	diamicton	Tiskilwa Fm., Delavan M.
B6	550.50		15	9	70	21	26	49	25	diamicton	Tiskilwa Fm., Delavan M.
B5	549.00	0	10	29	52	19	4	84	12	silt and silty diamicton	Tiskilwa Fm., Delavan M.
B4	548.50	0	16	24	57	19	5	81	14	silt and silty diamicton	Tiskilwa Fm., Delavan M.
B3	545.50	0	12	43	41	16	1	88	11	silt and silty diamicton	Tiskilwa Fm., Delavan M.
B-2B	544.50	8	23	11	67	22	28	47	25	diamicton	Tiskilwa Fm., Delavan M.
B2-A	542.50	7	25	13	65	22	26	52	22	diamicton	Tiskilwa Fm., Delavan M.
4	519.00	13	17	9	75	16	36	43	21	diamicton	Glasford Fm., Hulick M.
3	518.25	8	24	13	66	21	39	48	13	diamicton	Glasford Fm., Hulick M.
2	516.50	12	24	11	68	21	47	43	10	diamicton	Glasford Fm., Hulick M.
B13	516.25	11	17	11	66	23	32	45	23	diamicton	Glasford Fm., Hulick M.
B2	516.00	15	24	9	64	27	32	44	24	diamicton	Glasford Fm., Hulick M.
B1	514.00	13	20	15	66	19	52	36	12	diamicton	Glasford Fm., Hulick M.
1	513.50	11	15	12	66	22	42	43	15	diamicton	Glasford Fm., Hulick M.

Table B2-1a. XRD analyses of clay and bulk powder and grain size (pipet) analyses from Stop 2-1, the Sister's Section.

SplNo.	ElevTop	Cc*	D*	E	I	K+C	Sand	Silt	Clay	Lithology	Lithostratigraphic unit
AA	597.7	4	30	15	71	14	35	40	26	diamicton	Tiskilwa Fm., undivided
BB	593.7	3	22	12	75	13	46	47	7	diamicton	Tiskilwa Fm., undivided
CC	589.7	3	19	16	70	14	31	44	25	diamicton	Tiskilwa Fm., undivided
DD	589 2	0	33	26	60	14	2	89	8	silt loam	Peoria Silt, Morton Tongue
EE	588.2	0	29	30	56	14	1	90	9	silt loam	Peoria Silt, Morton Tongue
FF	587.2	1	22	26	59	15	2	91	8	silt loam	Peoria Silt, Morton Tongue
GG	586.2	1	29	27	59	14	0	92	8	silt loam	Peoria Silt, Morton Tongue
HH	585.2	0	25	28	55	17	1	92	7	silt loam	Peoria Silt, Morton Tongue
II	584 2	0	25	33	52	15	1	93	6	silt loam	Peoria Silt, Morton Tongue
JJ	583 2	1	20	28	53	19	1	93	7	silt loam	Peoria Silt, Morton Tongue
KK	582.2	0	32	46	41	13	1	89	10	silt loam	Peoria Silt, Morton Tongue
LL	581 2	1	8	44	37	19	4	88	8	silt loam	Peoria Silt, Morton Tongue
MM	580 2	1	1	39	31	29	4	87	9	silt loam	Roxana Silt
NN	579 2	0	0	45	25	30	1	91	8	silt loam	Roxana Silt
OO	578 2	0	8	39	41	20	0	90	10	silt loam	Roxana Silt
PP	577 2	0	1	34	47	19	0	90	10	silt loam	Roxana Silt
QQ	576 2	0	5	45	38	17	0	89	11	silt loam	Roxana Silt

RR	575.2	0	3	47	39	14	1	87	12	silt loam	Roxana Silt
SS	574.2	0	10	48	39	14	0	88	12	silt loam	Roxana Silt
TT	573.2	2	12	45	42	13	1	86	13	silt loam	Roxana Silt
UU	572.2	1	5	40	39	20	1	86	13	silt loam	Roxana Silt
VV	571.2	0	1	36	38	26	3	89	8	silt loam	Roxana Silt
WW	570.2	0	0	42	31	26	3	83	15	silt loam	Roxana Silt
XX	569.2	0	0	49	27	24	4	86	10	silt loam	Roxana Silt
YY	568.2	0	1	47	27	27	6	72	22	silt loam	Roxana Silt
A	571.6	0	1	42	30	28	8	81	11	silt loam	Roxana Silt
B	570.6	0	1	49	23	28	10	69	21	silt loam	Roxana Silt
C	569.6	0	1	51	23	26	11	76	13	silt loam	Roxana Silt
D	568.2	0	0	55	21	24	13	65	21	silt loam	Roxana Silt
E	567.2	0	0	15	40	45	38	44	18	loam	Pearl Fm., tongue Pe-3
F	565.8	0	0	15	41	44	36	48	16	clay loam	Pearl Fm., tongue Pe-3
G	564.8	0	0	32	37	31	24	48	28	clay loam	Pearl Fm., tongue Pe-3
H	563.7	0	1	30	57	13	25	40	35	clay loam	Pearl Fm., tongue Pe-3
I	562.5	0	0	25	52	23	51	23	26	silty sand	Pearl Fm., tongue Pe-3
J	561.2	0	1	30	57	14	64	17	19	sandy loam	Pearl Fm., tongue Pe-3
K	560.5	0	1	50	33	17	58	16	25	sandy loam	Pearl Fm., tongue Pe-3
L	559.5	0	1	40	46	14	64	18	18	sandy loam	Pearl Fm., tongue Pe-3
M	558.5	0	0	7	68	24	29	46	25	diamicton	Glasford Fm., Radnor M.
N	558.0	0	1	13	63	24	25	44	31	diamicton	Glasford Fm., Radnor M.

Table B2-1b. Radiocarbon age determinations for Core ISGS I-1081 located NW NE SE 35, T. 31 N., R. 2 W, Putnam Co.

Spl. No.	Lab No.	ElevTop	14C yr BP	cal yr BP	Material dated	Deposit sampled	Lithostratigraphic unit
A	A-0535	528.5	20,780+/-140	24,892+/-374	plant debris	silt, organic, calcareous, 5Y3/1	Equality Fm.
B	ISGS-5649	518.75	21,320+/-570	25,616+/-801	plant debris	silt loam, organic, calcareous, 5Y2/1	Equality Fm.
C	A-0517	518.55	21,500+/-80	25,754+/-346	plant debris	silt loam, organic, calcareous, 5Y2/1	Equality Fm.
D1	ISGS-5630	508.5	21,350+/-200	25,572+/-412	plant debris	silt loam, calcareous, 5Y4/1	Equality Fm.
D2	A-0518	508.5	21,650+/-100	25,992+/-335	plant debris	silt loam, calcareous, 5Y4/1	Equality Fm.
E	ISGS-5651	498.5	24,260+/-760	29,099+/-805	plant debris	silt loam, heavy, calcareous, 5Y4/1	Equality Fm.

Table B2-2. XRD analyses of bulk powder and clay from Stop 2-2, the December Section.

SplNo.	ElevTop	Cc*	D*	E	I	K+C	Sand	Silt	Clay	Lithology	Unit
A	555.5	0.2	0.4	33	39	28	--	--	--	silt	Roxana Silt
B	554.5	0.1	0.3	7	67	26	--	--	--	diamicton	Radnor M.

C	553.0	0.3	0.4	5	87	8	--	--	--	diamicton	Radnor M.
D	551.0	0.2	0.5	5	91	4	--	--	--	diamicton	Radnor M.
E	549.0	0.3	19.7	3	88	9	--	--	--	diamicton	Radnor M.
F	547.0	0.1	28.6	3	89	8	--	--	--	diamicton	Radnor M.
G	545.0	0.3	19.9	3	91	6	--	--	--	diamicton	Radnor M.
H	543.0	0.2	23.0	3	91	6	--	--	--	silty sand	Pearl Fm., tongue Pe-2
I	541.0	0.5	0.5	9	85	6	--	--	--	silty sand	Pearl Fm., tongue Pe-2
J	539.0	0.1	0.4	6	88	6	--	--	--	silty sand	Pearl Fm., tongue Pe-2
K	537.0	0.7	29.5	1	75	23	--	--	--	diamicton	Hulick M.

Table B2-3. XRD analyses of bulk powder and clay from Stop 2-3, the Kettle Section.

SplNo.	ElevTop	Cc*	D*	E	I	K+C	Sand	Silt	Clay	Lithology	Unit
A1	566	1.1	18.1	7	82	11	--	--	--	diamicton	Radnor M.
C	538	3.0	26.4	4	65	31	--	--	--	diamicton	Hulick M.
D	533	5.6	27.8	4	69	27	--	--	--	diamicton	Hulick M.

Table B2-4a. XRD analyses of bulk powder and clay from Core I-1083 at Stop 2-4, the Sandy Creek Section.

SplNo.	ElevTop	Cc*	D*	E	I	K+C	Sand	Silt	Clay	Lithology	Unit
A	643	3.4	27.7	4	85	11	--	--	--	diamicton	Batestown M.
B	642	2.9	29.4	8	76	16	--	--	--	diamicton	Batestown M.
C	635.5	3.3	23.4	6	76	18	--	--	--	diamicton	Tiskilwa Fm.
D	629.5	6.5	16.7	6	66	28	--	--	--	diamicton	Tiskilwa Fm.
E	625.5	3.7	24.7	5	67	28	--	--	--	diamicton	Tiskilwa Fm.
F	621	3.5	20.9	4	65	31	--	--	--	diamicton	Tiskilwa Fm.
G	617.5	1.7	34.7	4	67	29	--	--	--	diamicton	Tiskilwa Fm.
H	617	2.2	14.2	1	69	30	--	--	--	silt	unnamed silt
I	612.8	0.4	18.7	1	65	34	--	--	--	diamicton	Radnor M.
J	611	1.5	18.4	0	69	31	--	--	--	diamicton	Radnor M.
K	607	3.4	15.6	1	73	26	--	--	--	diamicton	Radnor M.
L	603	1.7	21.1	1	72	27	--	--	--	diamicton	Radnor M.
M	598 5	2.9	36.1	7	85	8	--	--	--	sand and gravel	Pearl Fm.
N	597 5	7.6	31.0	7	85	8	--	--	--	sand and gravel	Pearl Fm.

Table B2-4b. XRD analyses of bulk powder samples from Sandy Creek Section and Core I-1088 at Stop 2-4.

SplNo	ElevTop	Q2*	Kf*	Pf*	Cc*	D*	H*	Lithology	Unit
A	583.6	50.74	16.76	6.30	1.65	16.89	0.55	sand	Pearl Fm.

B	573.4	38.74	19.19	5.97	4.32	24.42	0.22	sand	Pearl Fm.
C	559	57.69	15.43	2.96	3.32	14.75	0.23	sand	Pearl Fm.
E	539.3	67.24	10.66	2.33	6.02	9.47	0.44	sand	Pearl Fm.
F	523.9	75.03	4.42	6.79	2.09	7.08	0.57	sand	Pearl Fm.
G	518	39.89	15.62	9.74	2.13	25.67	0.22	sand	Pearl Fm.
H	515	69.34	7.64	8.71	2.50	6.43	0.55	sand	Pearl Fm.
1088-A	454.0	43.11	3.21	6.81	5.76	36.68	0.12	sand	Pearl Fm.
1088-C	442.5	70.00	6.94	7.74	1.51	9.50	0.14	sand	Pearl Fm.
1088-D	432.0	52.19	14.68	15.35	1.28	8.61	0.30	sand	Pearl Fm.
1088-F	424.0	61.92	22.70	5.82	0.92	2.59	0.15	sand	Sankoty M.
1088-G	418.0	79.65	11.80	3.19	0.54	0.66	0.19	sand	Sankoty M.
1088-H	412.0	85.83	4.18	3.93	1.55	1.19	0.15	sand	Sankoty M.
1088-I	406.0	69.37	21.79	2.28	0.26	0.43	0.25	sand	Sankoty M.
1088-J	399.5	75.07	3.37	7.67	1.18	5.81	0.17	sand	Sankoty M.

APPENDIX C – Interpreting Outwash Sequences

The Importance of Lithofacies Codes and Bounding Surfaces

Geologists' attempts to make meaningful interpretations of past outwash environments have been hampered by the lack of a systematic means to describe sand-and-gravel deposits in a way that leads to understanding flow conditions when the sequence was deposited.

Lithofacies Codes - A simple and effective lithofacies code combining grain size and sedimentary structure was developed by Miall (1978) for braided-stream deposits. This simple code combined a capital letter for grain size, such as *G* for gravel, with a lower case letter for sedimentary structure, such as *p* for planar cross beds. Thus, sediment designated as Gp constitutes planar cross-bedded gravel. The importance of the lithofacies code, besides being a convenient, simple way to describe sand-and-gravel deposits, is that the sedimentary structures and grain size can be related to flow-regime bedforms (Fig. C-1) to gain an understanding of past streamflow conditions.

Kemmis et al. (1988) expanded Miall's code to allow for greater subdivision of gravel size and sorting as well as adding various sedimentary structures observed in Wisconsin Episode outwash sequences (Table C-1). In the field, one recognizes a large range in gravel sizes, so Kemmis et al. (1988) subdivided gravels into pebble gravel (designated PG), cobble gravel (CG), and boulder gravel (BG). Gravel deposits also differ significantly in sorting, so the expanded lithofacies code provides a simple means to describe this as well: the designation cs standing for well sorted, clast-supported gravels; ms standing for poorly sorted, matrix-supported gravels; and cm standing for intermediately sorted, clast-to-matrix supported gravels. To make a clearer distinction between the grain-size and sedimentary structure designations, the expanded lithofacies code also puts the sedimentary structure designations in parentheses. Here are examples of lithofacies designations using the expanded code of Table C-1:

PGms(t)	trough cross beds of matrix-supported pebble gravel (i.e., trough cross beds of sandy pebble gravel)
S(m)	massive sand (description should also include designation of sand texture as either very fine, fine, medium, or coarse)
F(l)	laminated fine-grained sediment (fine-grained texture also should be described in greater detail using either USDA textures or the Unified Soil Classification)

Study of the vertical and lateral changes in lithofacies, combined with an understanding of the bounding surfaces within the outwash sequence, can lead to an understanding of past stream behavior as the sequence was deposited, as demonstrated at field trip stop 1-7.

Bounding Surfaces - Examination of any outwash exposure reveals a seemingly bewildering array of unconformities on all scales. However, these unconformities can be grouped, or ordered, in important ways to minimize this bewilderment. First-order boundaries are those that occur between individual beds or crossbeds. Some beds or crossbeds occur in groups, and the boundaries between these groups can be designated as second-order bounding surfaces. Channel fills may be comprised of several groups of beds or crossbeds, and the boundaries of these channel fills constitute a third-order bounding surface. In turn, valley fills may be composed of multiple channel fills, and these fill boundaries constitute fourth-order bounding surfaces for the outwash sequence, and so on.

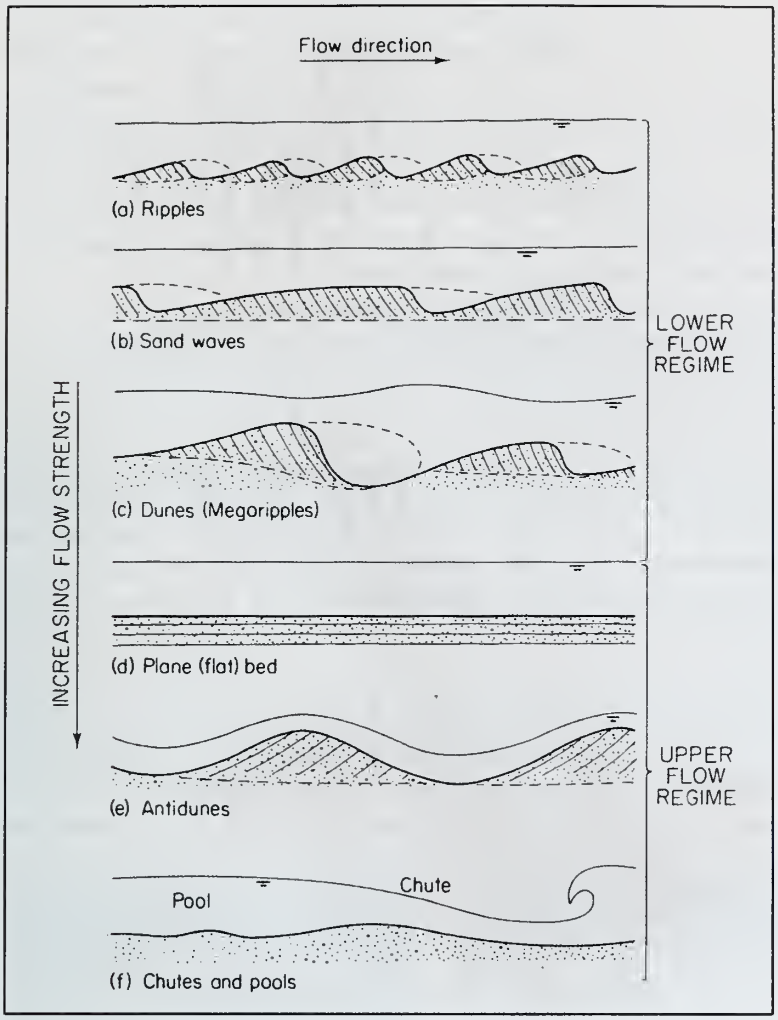


Figure C-1. Fluvial bedforms abruptly change with increasing flow velocity and depth (flow strength) from lower flow regime through upper flow regime (from Blatt et al. 1980). Relating sedimentary structures determined from lithofacies codes to these past flow-regime bedforms enables reconstruction of past flow conditions during deposition of the sediments. (from Blatt, Harvey, Middleton, Gerard V., and Murray, Raymond C, Origin of Sedimentary Rocks, 2nd Edition, © 1980. Reprinted by permission of Pearson Education, Inc. Upper Saddle River, NJ).

The key to unraveling complex outwash sequences and understanding past outwash conditions, then, depends on recognizing the different order bounding surfaces in the sequence and describing the deposits in a way that can be related to streamflow conditions, such as flow-regime bedform concepts.

Table C-1. Lithofacies code for Fluvial and Glaciofluvial Deposits (adapted from Kemmis et al. 1988)

GROSS PARTICLE SIZE – first symbols

BG	boulder gravel	cm	clast-supported
CG	cobble gravel	ms	matrix-supported
PG	pebble gravel	cm	clast-to-matrix supported
S	sand		
F	fines		

BEDDING STRUCTURES[6] - second symbols, in parentheses

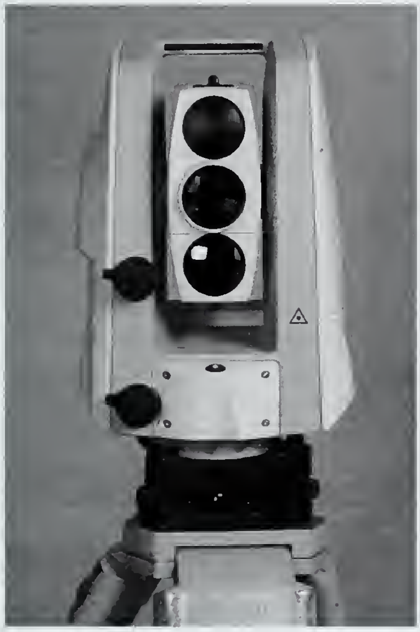
(m)	massive
(pl)	planar-bedded; crudely horizontal, may be slightly undulatory
(h)	horizontally laminated; may be slightly undulatory
(r)	ripple-drift cross-laminated (various types)
(t)	trough cross-bedded; size (scale) and single or multiple sets noted on log
(w)	wedge cross-bedded; size (scale) and single or multiple sets noted on log
(p)	planar cross-bedded; size (scale) and single or multiple sets noted on log
(c)	cross-bedded deposits with complex upper and lower contacts; generally large-scale, solitary sets: lower contacts commonly undulatory over irregular channel floor; upper contacts commonly undulatory, truncated by overlying bedding structures
(la)	lateral-accretion deposits
(ccf)	channel cut-and-fill; massive or simple structures mimicking the scoured channel cross-section
(ccfc)	channel cut-and-fill structure with complex facies changes within the fill (see Ramos and Sopena, 1983)
(ccft)	channel cut-and-fill structure with transverse fill (see Ramos and Sopena, 1983)
(ccfms)	channel cut-and-fill structure with multi-storey fill (see Ramos and Sopena, 1983)
(lag)	lag at base of channel or cross-bed set
(g)	normally graded
(ig)	inversely graded
(n-i)	normal to inversely graded
(i-n)	inversely to normally graded
(l)	low angle ($<10^{o}$) crossbeds
(e)	erosional scours with intraclasts
(s)	broad shallow scours
(sc)	laminated to massive fines
(-t)	various bedding structures comprising deltaic topset beds
(-f)	various bedding structures comprising deltaic foreset beds
(-b)	various bedding structures comprising deltaic bottomset beds

APPENDIX D - Reflectorless Total Station for Measuring Inaccessible Sections

High, unstable outcrops like this one in the high terrace of the Illinois River at Lacon cannot be accurately measured using conventional mapping techniques because of the danger involved. To date, such sections have been observed, photographed, and given a generalized description, but no measurements or quantitative information have been available for scientists and engineers. However, newly affordable surveying technology, the reflectorless total station (RTS), makes it possible to accurately determine elevations and locations as well as aid in sediment description. Furthermore, this technology allows an individual to survey what once required a three person crew.

The RTS (Figure 1) works by sending a pulsed laser to a target, such as a bedding plane. The laser electronic distance measuring (EDM) measures the integer and phase of the reflected light from the target. This outcrop was measured by surveying control points using high-precision, dual-frequency GPS receivers (Figure 2) achieving precision of 0.02 meters (H) and 0.03-0.09 m (V). The RTS instrument records the data digitally, which can then be downloaded to a computer and used in any number of different applications. Another advantage of using the RTS instrument for out crop description is that the RTS eyesight works like a telescope, providing a close-up view of the sediments being described, making it relatively easy to characterize sorting and grain size.

At each profile, every bedding plane was surveyed and the lithofacies described. Table D-1 gives an example of a part of one of the profile descriptions. Because each unit and bed is surveyed in absolute X,Y,Z coordinates, later surveys at this and nearby pits can be compared with previous surveys to map unit surfaces as well as construct profiles and 3-D models.



Since error is a part of every survey, care must be taken to minimize errors in establishing horizontal and especially vertical control points used to setup and orientate the RTS. At this site, the RTS was setup over one control point and backsighted to another. Comparison to a third control point found the setup was correct within 8 millimeters (H) and 0.1 m (V), about 4 inches difference in vertical. As for any technical instrument, use of precise, advanced technology improves the convenience and accuracy of surveying but requires a high level of care to achieve useful, accurate results. Since this system does not rely upon prisms and the reflected light from the sediment is reduced, some dark targets are unmeasureable. As always, sloppy procedures at any point in a survey can lead to puzzling, unusable data.

Figure D-1. Trimble TTS500 reflectorless total station.

Figure D-2. Trimble 4000 GPS dual frequency receiver with 'pizza dish' antenna and TTS 500 total station.

Table D-1. Portion of description and survey coordinates at Midwest Material, Lacon, IL

28 July 04	**Midwest Materials Co.**		**Lacon, IL**	**Marshall Co.**	
Observation	Easting	Northing	Elevation	Description	
P1175	298749.67	4546138.95	156.45	top of section	
P1176	298749.18	4546138.9	155.45	PG ms (t)	w/ occ. cobble
P1177	298748.72	4546137.27	154.23	PG ms (t)	
P1178	298742.67	4546137.17	149.75	CG ms (ccf) - PG ms (ccf)	incl. clast-supported PC
P1179	298742.6	4546137.19	149.54	S (t)	fine sand
P1180	298742.5	4546137.18	149.38	S (t)	fine sand w/ few pebbles bedding contact
P1181	298742.35	4546137.2	149.07	PG ms (t)	
P1182	298742.23	4546137.21	148.78	PG ms (t)	

APPENDIX E – Detailed description of Stop 1-7, Profile 1

MIDWEST MATERIAL COMPANY
SW ¼, SE ¼ Section 24, T. 30 N., R. 3 W., Marshall County, IL
Described by T. Kemmis, E. Hajic, A. Stumpf, C. Stohr, R.S. Nelson, and J. Dexter
July 28, 2004
Elevation of top of stripped section: 156.08 m (512.06 ft)

ElevTop (ft)	Top Depth (ft)	Thickness (ft)	Lithofacies	Description
Unit z – total exposed thickness: 21.03 ft				
512.06	0.00	2.17	PGms(t)	Trough cross-bedded matrix supported pebble gravel; some foresets are entirely pebble gravel.
509.90	2.2	3.28	PGms(t)	Trough cross-bedded matrix-supported pebble gravel, the gravel occurring as individual clasts along foresets.
506.62	5.4	3.41	PGms(t)	Trough cross-bedded matrix-supported pebble gravel; some foresets are clast-supported very fine pebbles; large gravels occur as isolated clasts within the crossbed sets.
503.21	8.9	12.17	CGms(ccf)-PGms(ccf)	Interbedded planar beds of clast-supported pebble gravel and coarse sand with isolated cobbles, the beds mimicking simple U-shaped channel geometry; some cobble to small boulder size subangular to subrounded diamicton clasts (armored mud balls) in the lower 1.5 m of the channels. Angular unconformity at the base of this unit. This is the coarsest exposed unit in the terrace sequence.
Unit y – total thickness: 27.82 ft				
491.04	21.0	0.72	PGms(t)	Trough cross-bedded matrix-supported pebble gravel composed of approximately 15 percent fine to medium pebbles.
490.32	21.8	0.98	PGms(t)	Trough cross-bedded matrix-supported pebble gravel.
489.33	22.7	3.58	S(t)-PGms(t)	Trough cross-bedded sand with occasional clasts of pebble gravel.
485.76	26.3	2.72	S(t)-PGms(t)	Trough cross-bedded sand with occasional clasts of pebble gravel.
483.03	29.0	1.44	PGms(t)	Trough cross-bedded matrix-supported pebble gravel with occasional foresets of clast-supported pebble gravel.
481.59	30.5	0.95	S(t)-PGms(t)	Trough cross-bedded sand with occasional clasts of pebble gravel.
480.64	31.4	0.66	PGms(t)	Trough cross-bedded matrix-supported pebble gravel.
479.98	32.1	0.89	PGms(t)	Trough cross-bedded matrix-supported pebble gravel.
479.09	33.0	0.49	S(t)	Trough cross-bedded sand; occasional clasts of pebble gravel.
478.60	33.5		S(t)	Trough cross-bedded sand; occasional clasts of pebble gravel.
478.64	33.4	3.81	S(t)	Trough cross-bedded sand; occasional clasts of pebble gravel.
474.83	37.2	0.20	Dmm	Matrix-supported diamicton, thickens and thins across the outcrop; separates upper and lower cosets of trough cross-bedded sands and pebble gravel.
474.63	37.4	2.13	PGms(t)	Trough cross-bedded matrix-supported pebble gravel; mostly pebble gravel.
472.50	39.6	3.22	S(t)	Trough cross-bedded fine sand; few clasts of pebble gravel.
469.29	42.8	2.62	PGms(t)	Trough cross-bedded matrix-supported pebble gravel; irregular, erosional lower contact.

466.66	45.4	0.49	Dmm	Matrix-supported diamicton.
466.17	45.9	1.51	PGms(t)	Trough cross-bedded matrix-supported pebble gravel with some foresets composed of clast-supported pebble gravel.
464.66	47.4	0.26	Dmm	Matrix-supported diamicton.
464.40	47.7	0.66	PGms(t)-CGms(t)	Trough cross-bedded matrix-supported pebble and cobble gravel.
463.74	48.3	0.52	CGcs(pl)	Planar-bedded clast-supported cobble gravel. Angular unconformity at the base of this unit.
Unit x – total exposed thickness: 14.07+ ft				
463.22	48.9	0.33	S(m)	Massive sand.
462.89	49.2	0.69	PGms(t)	Trough cross-bedded matrix-supported pebble gravel with finer material at the base of the set.
462.20	49.9	1.44	PGms(t)	Trough cross-bedded matrix-supported pebble gravel.
460.76	51.3	0.89	PGms(t)	Trough cross-bedded matrix-supported pebble gravel with some fine sand foresets.
459.87	52.2	0.52	PGms(t)	Trough cross-bedded matrix-supported pebble gravel; base not exposed.
459.34	52.7	10.20	Slump	
449.14			Base of exposure	

APPENDIX F – Detailed description of Stop 2-4

SANDY CREEK SECTION

SW ¼, NE ¼, Section 3, T. 30 N., R. 2 W., Marshall County, IL
Described by T. Kemmis, D. McKay, R. Berg
September 16, 2004

ElevTop (ft)	Top Depth (ft)	Thickness (ft)	Lithofacies	Description
Described Section A				
Exposed Unit IV – total exposed thickness: 10.5 ft				
600.0	0.0	5.6	PGcs(pl)	Planar-bedded, clast-supported medium pebble gravel
594.4	5.6	1.0	CGcs(pl)	Planar-bedded, clast-supported cobble gravel with medium pebble to sand matrix and cobbles up to 20 cm in diameter
593.4	6.6	1.9	PGms(pl)	Planar-bedded, matrix-supported pebble gravel with occasional cobbles up to 15 cm in diameter
591.5	8.5	2.0	BGcm(pl)	Planar-bedded, clast-to-matrix-supported boulder gravel with cobbles and boulders 15 to 50 cm in diameter; coarser textured toward the center of the channel; unconformity at base.
Exposed Unit III – total thickness: 46.9 ft				
589.5	10.5	2.3	S(pl)	Thin to medium-bedded, planar fine-to-medium sand; some fine gravel in lower 30 cm of the bed
587.2	12.8	0.2	F(m)	Massive silt, iron-stained, soft-sediment deformation along lower boundary
587.0	13.0	1.1	PGcs(m)	Massive clast-supported very fine pebble gravel in lenticular bed about 6 m wide
585.9	14.1	0.3	F(l)	Laminated silt, some laminae wavy bedded
585.6	14.4	0.3	PGcs(m)	Massive clast-supported very fine pebble gravel in lenticular bed
585.3	14.7	4.0	F(m)-S(r)	Thin to medium-bedded massive silt and massive to ripple-drift cross-laminated fine sand; foreset laminae dip to west-southwest; sand beds typically 3-7 cm thick, silt beds typically 5-20 cm thick; silt beds occasionally deformed by soft-sediment deformation
581.3	18.7	2.3	F(m)	Massive silt, some iron staining at base
Described Section B (2 m west of Section A)				
579.0	21.0	2.0	S(r)-PGcm(m)	Thinly bedded ripple-drift cross-laminated fine sand and massive, clast-supported fine pebble gravel; foreset laminae dip to west-southwest
577.0	23.0	1.9	PGms(m)	Massive matrix-supported fine to medium pebble gravel
575.1	24.9	3.3	PGms(pl)-S(pl)	Planar-bedded matrix-supported fine to medium pebble gravel and medium sand
571.8	28.2	3.3	PGcm(m)	Massive clast-to-matrix-supported medium to fine pebble gravel
568.5	31.5	14.4	PGms(t)-S(t)	Trough cross-bedded matrix-supported pebble gravel and fine to medium sand; troughs generally 20 to 40 cm thick and 2 to 4 m long; foresets dip to west-southwest
554.1	45.9	0.5	F(m)	Massive silt filling in shallow troughs on top of underlying bed
553.6	46.4	2.8	PGcs(pl)	Planar-bedded clast-supported coarse to fine pebble gravel
550.8	49.2	0.3	F(m)	Discontinuous massive coarse silt and very fine sand filling shallow trough 12 to 15 m wide on top of

				underlying bed
Described Section C (3.5 m east of Section B)				
550.5	49.5	7.9	PGcs(pl)	Planar-bedded clast-supported coarse to medium pebble gravel
Exposed Unit II – total thickness: 20.4 ft				
542.6	57.4	3.6	PGms(t)-S(t)	Large-scale trough cross-bedded matrix-supported pebble gravel and find sand; occasional coal fragments; foresets dip to west-southwest
539.0	61.0	2.0	S(pl)	Thinly bedded to laminated planar-bedded fine to very fine sands, individual beds commonly 2-5 mm thick
Described Section D (5 m west of Section C)				
537.0	63.0	6.6	S(r)-S(pl)	Ripple-drift cross-laminated very fine to fine sand with occasional planar beds; undulatory erosional contact at base; foresets dip toward the west-southwest; some discontinuous laminae of sand-sized coal clasts present; ISU geologists note climbing ripples in this interval.
530.4	69.6	8.2	Interbedded PGms(t)-S(t)	Medium scale trough cross-bedded matrix-supported pebble gravel and fine to medium sand, individual sets 20 to 40 cm thick, some coal fragments along foresets; foresets dip to west-southwest
Exposed Unit I – total exposed thickness: 19+ ft				
522.2	77.8	2.9	S(pl)	Thinly bedded planar-bedded to laminated fine to very fine sand; some secondary iron staining
Described Section E (3 m east of Section D)				
519.3	80.7	3.3	S(r)	Ripple-drift cross-laminated fine sand, foresets dip to east-southeast, upper 10-20 cm cemented with secondary carbonate; ISU geologists note flute casts in this interval.
516.0	84.0	3.9	PGms(t)-S(t)	Trough cross-bedded matrix-supported pebble gravel and sand in sets 30 to 40 cm thick dipping to the southeast; pinkish gray; ISU geologists note flute casts in this interval.
Described Section F (10 m east of Section E)				
512.1	87.9	8.9	PGcs(t)	Set of large-scale trough cross-bedded clast-supported coarse to fine pebble gravel 2.7 m thick with occasional cobbles, base not exposed; foresets to southeast (135°) with 30° dip) and are commonly 2 to 5 cm thick; gravels are primarily subrounded and spherical, resulting in fabric indicators being rare and inconclusive; represents either a mega-dune or transverse channel fill, but exposure too limited to determine
503.2	96.8	29.5	Slump	Slump to base of section
473.7	126.3			Base of section

Notes:
1. Described by Tim Kemmis, Don McKay, and Dick Berg on September 16, 2004 using lithofacies code adapted from Kemmis et al. (1988).
2. The section exposes Ancient Mississippi River sediments deposited at different times prior to the close of the Illinois Episode.
3. All depths are approximate. Upper 3.2 m of section inaccessible and thicknesses estimated visually.
4. The top elevation was used as datum, and is estimated from the Henry, ILL. USGS 7.5' Topographic Quadrangle Map.
5. All sands and gravel beds in this section are oxidized. Many of the finer grained silt beds are reduced.
6. Ripple-drift cross-lamination and trough cross-bed dip directions are difficult to measure precisely, thus only generalized dip direction indicated.
7. Exposure limited because of extensive slumping. The geometry of some beds could not be precisely determined.
8. All beds appear to fill broad, very shallow channels.
9. The exposed section records fluctuating flow through time with 4 groups of sediment related to discrete periods of sedimentation, unconformities separating the different groups.

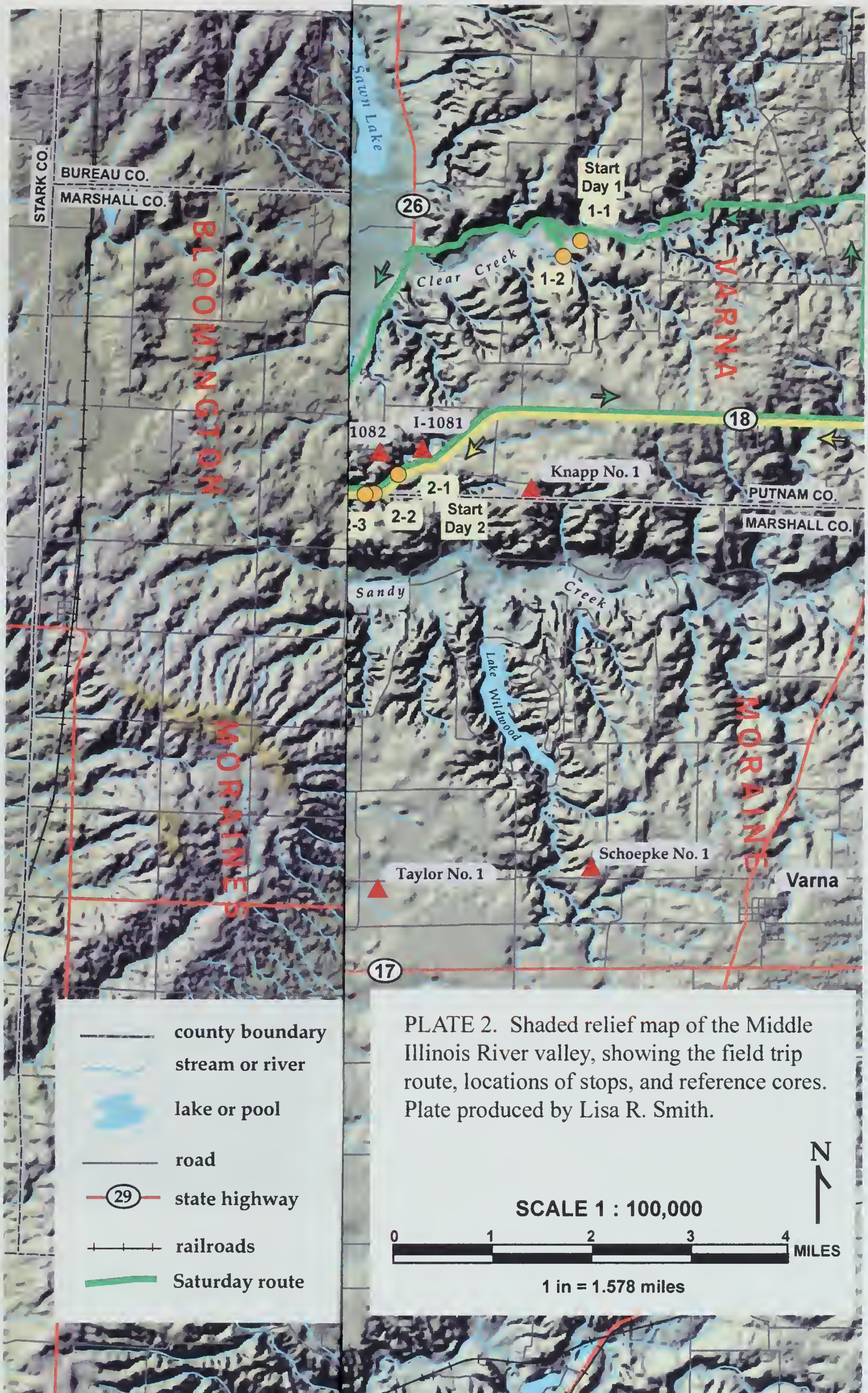


PLATE 2. Shaded relief map of the Middle Illinois River valley, showing the field trip route, locations of stops, and reference cores. Plate produced by Lisa R. Smith.

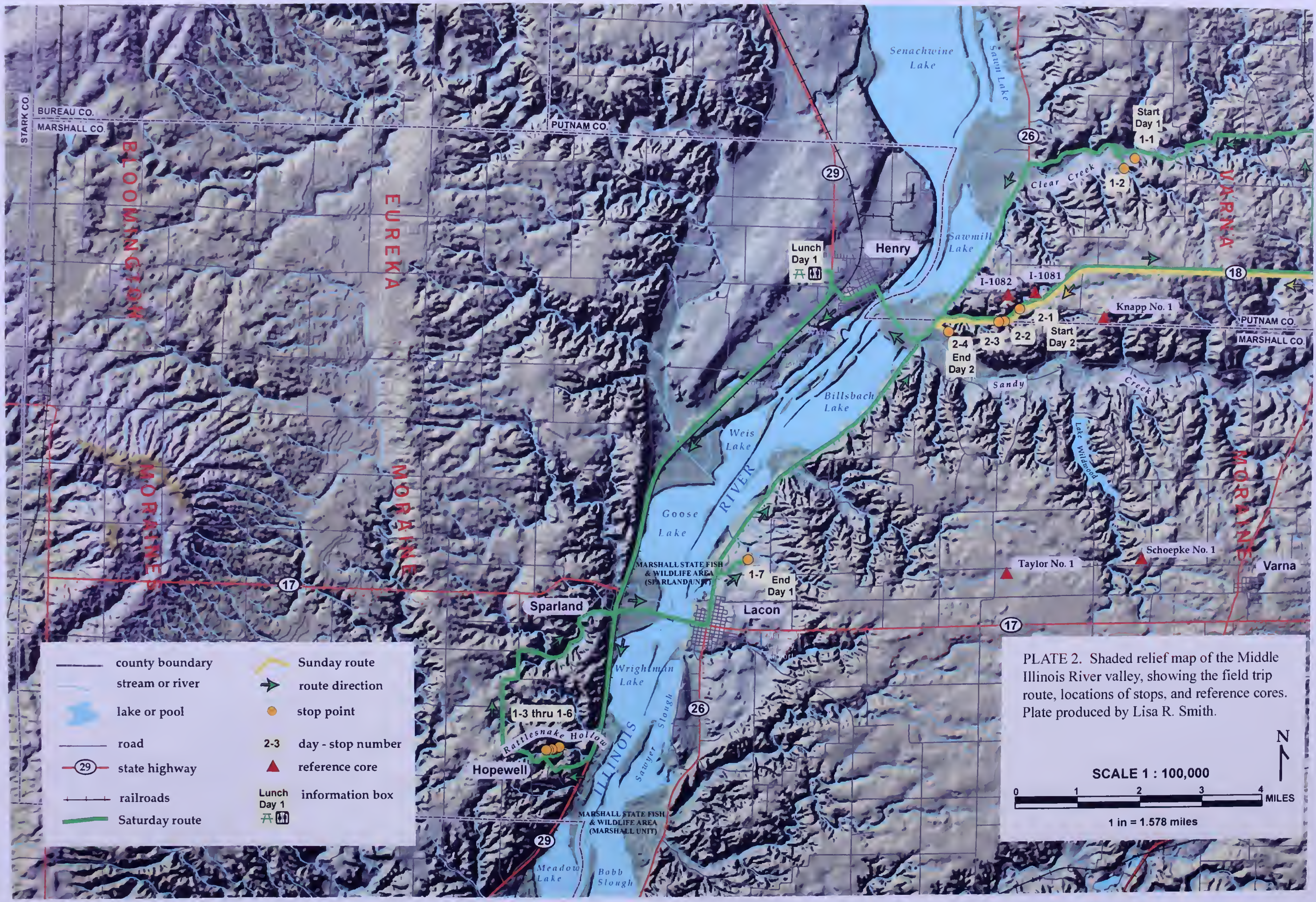


PLATE 2. Shaded relief map of the Middle Illinois River valley, showing the field trip route, locations of stops, and reference cores. Plate produced by Lisa R. Smith.

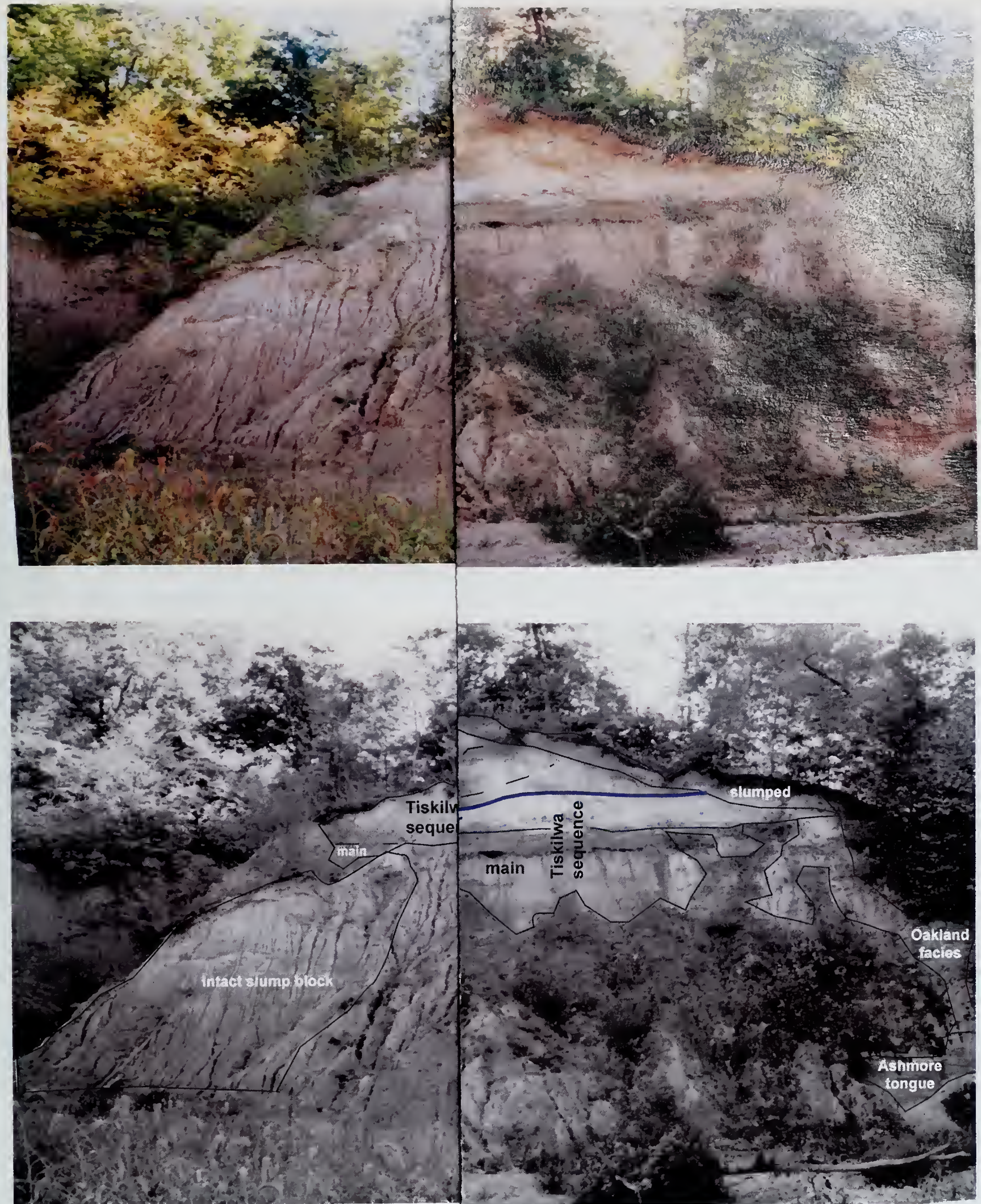


Plate 3. Photomosaic of the Clear Creek are indicated. Sequence boundaries are blue.
Photos by A. Hansel, photomos

Plate 3. Photomosaic of the Clear Creek Section, NW¼, NW¼, NE¼, Sec. 19, T31N, R1W, Putnam Co., IL, based on 2002 photos. Some stratigraphic units are indicated. Sequence boundaries are blue. Photos by A. Hansel, photomosaic by D. Byers.

Meetings of the Midwest Friends of the Pleistocene

1	1950	Eastern Wisconsin	
2	1951	Southeastern Minnesota	H.E. Wright, Jr. and R.V. Ruhe
3	1952	Western Illinois and eastern Iowa	P.R. Shaffer and W.H. Scholtes
(4)	1953	Northeastern Wisconsin	F.T. Thwaites
(5)	1954	Central Minnesota	H.E. Wright, Jr., and A.F. Schneider
6	1955	Southwestern Iowa	R.V. Ruhe
(7)	1956	Northwestern lower Michigan	J.H. Zumberge and W.N. Melhorn
8	1957	South-central Indiana	W.D. Thornbury and W.J. Wayne
9	1958	Eastern North Dakota	W.M. Laird and others
10	1959	Western Wisconsin	R.F. Black
11	1960	Eastern South Dakota	A.G. Agnew and others
12	1961	Eastern Alberta	C.P. Gravenor and others
13	1962	Eastern Ohio	R.P. Goldthwait
14	1963	Western Illinois	J.C. Frye and H.B. Willman
15	1964	Eastern Minnesota	H.E. Wright, Jr. and E.J. Cushing
16	1965	Northeastern Iowa	R.V. Ruhe and others
17	1966	Eastern Nebraska	E.C. Reed and others
18	1967	South-central North Dakota	Lee Clayton and T.F. Freers
19	1969	Cyprus Hills, Saskatchewan and Alberta	W.O. Kupsch
20	1971	Kansas and Missouri Border	C.K. Bayne and others
21	1972	East-central Illinois	W.H. Johnson, L.R. Follmer and others
22	1973	West-central Michigan & east-central Wisconsin	E.B. Evenson and others
23	1975	Western Missouri	W.H. Allen and others
24	1976	Meade County, Kansas	C.K. Bayne and others
25	1978	Southwestern Indiana	R.V. Ruhe and C.G. Olson
26	1979	Central Illinois	L.R. Follmer, E.D. McKay and others
27	1980	Yarmouth, Iowa	G.R. Hallberg and others
28	1981	Northeastern lower Michigan	W.A. Burgis and D.F. Eschman
29	1982	Driftless Area, Wisconsin	J.C. Knox and others
30	1983	Wabash Valley, Indiana	N.K. Bleuer and others
31	1984	West-central Wisconsin	R.W. Baker
32	1985	North-central Illinois	R.C. Berg and others
33	1986	Northeastern Kansas	W.C. Johnson and others
34	1987	North-central Ohio	S.M. Totten and J.P. Szabo
35	1988	Southwestern Michigan	G.J. Larson and G.W. Monaghan
36	1989	Northeastern South Dakota	J.P. Gilbertson
37	1990	Southwestern Iowa	E.A. Bettis III and others
38	1991	Mississippi Valley, Missouri and Illinois	E.R. Hajic W.H. Johnson and others
39	1992	Northeastern Minnesota	J.D. Lehr and H.C. Hobbs
40	1993	Door Peninsula, Wisconsin	A.F. Schneider and others
41	1994	Eastern Ohio and western Indiana	T.V. Lowell and C.S. Brockman
42	1995	Southern Illinois and southeast Missouri	S.P. Esling and M.D. Blum
43	1996	Eastern North Dakota & northwestern Minnesota	K.I. Harris and others
44	1998	North-central Wisconsin	J.W. Attig and others
45	1999	North-central Indiana & south-central Michigan	S.E. Brown, T.G. Fisher and others
46	2000	Southeastern NB and Northeastern KA	R.D. Mandel and E.A. Bettis III
47	2001	Northwestern ON and Northeastern MN	B.A.M. Phillips and others
48	2002	East-Central Upper Michigan	W.L. Loope and J.B. Anderton
49	2003	Southwest Michigan	B.D. Stone and K.A. Kincare and others
50	2004	Central Minnesota	A.R. Knaeble, G.N. Meyer and others

* No meetings were held in 1968, 1970, 1974, 1977, and 1997. The 1952 meeting that is commonly included in the list of Midwest FOP meetings as Southwestern Ohio was actually an Eastern FOP meeting in central Ohio, to which Midwest Friends were invited by Dick Goldthwait the previous week in Western Illinois.